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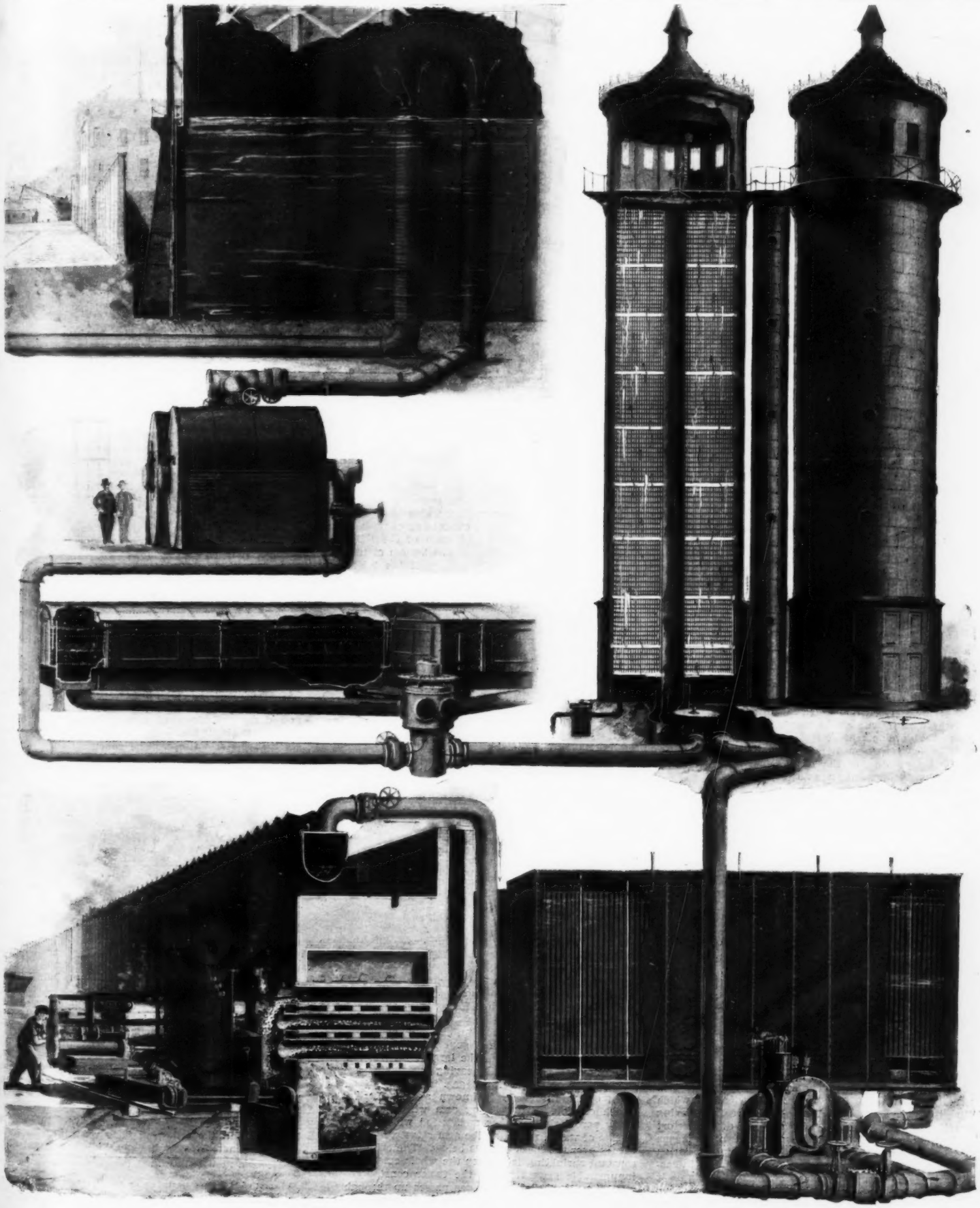



THE MANUFACTURE OF COAL GAS.

## MANUFACTURE OF ILLUMINATING GAS.

### I. COAL GAS.

IN the present illustrated description of the modern method of manufacturing coal gas, we have chosen the large station at the foot of Fourteenth Street, near the East River, in this city, as being thoroughly representative of the present state of the art, as carried out on a large scale. By the courtesy of Dr. Elliott, the chief chemist of the Consolidated Gas Company, our artist was enabled to make the accompanying drawings, in which the salient features of this vast plant are grouped together in such a way as to enable the reader to follow the process from the charging of the retorts to the final delivery to the city mains.

The station which is herewith illustrated is one of ten which are owned by this company, in three of which coal gas is manufactured, while the others are devoted to the manufacture of water gas. The Fourteenth Street station covers an area of several city blocks, and in the course of each year, 125,000 tons of bituminous coal are consumed in producing gas at the rate of from 3,000,000 cubic feet per day in the summer to 5,000,000 cubic feet per day in the winter season. The plant is in constant operation for the whole twenty-four hours, and although the exigencies of manufacture require that certain parts of it be briefly closed for repairs, there is no time in the year, or from year to year, in which the whole establishment is idle.

Illuminating gas is obtained from coal by the operation which is chemically known as destructive distillation, and technically as carbonization. The carbonization is accomplished by placing the coal in closed airtight retorts which are raised to the proper temperature for driving off the various gases and converting the coal into coke. The retorts employed at the works under construction are of the D-shaped pattern, and are manufactured of fire clay, which on account of its refractory nature and its cheapness and durability has been proved to be the best material for this purpose. The retorts are 25 inches in width, 14 inches in height, and 9 feet in length, and they are arranged in three tiers, as shown in the sectional view at the bottom of our first-page engraving. They are grouped in series of six. Each six constitutes a "bench," and each bench is supported within an arched setting, while below is provided a deep and somewhat narrow furnace, the air for the supply of which passes up from below through the fire bars. The heating furnace is charged with a portion of the coke which forms the solid residuum in the retorts. For purposes of economy, the furnaces are fired on the regenerative principle, only sufficient air being supplied through the fire bars for the production of carbon dioxide gas, which, passing up through the upper stratum of coke, serves to maintain it at a steady glow of heat, the final carbon monoxide gas being ignited and burnt beneath the lowest tier of the retorts by means of heated air, which is led in through special air ducts provided for the purpose. These ducts will be noticed in our sectional view of the retorts.

The view referred to shows one side of what is known as a "range" of retorts. In this particular range we see the front face of twelve benches which contain in all seventy-two retorts. On the opposite side, or what is technically known as the back of the range, are twelve other benches, thus making a total of 144 in all. There are in the Fourteenth Street station six of these ranges, and the total number of retorts will thus be seen to amount to 864. Each retort of the particular type shown can make 10,000 cubic feet of gas in every twenty-four hours.

Although the principles of coal gas manufacture are the same to-day as they were in the early days of the art, there has been a vast advance in the details of the plant, the development of special appliances and tools, and the general systematization of the work. Our illustrations show two of the most remarkable machines of recent design, known as the "charger" and "discharger," the latter being shown in some detail at the nearer end of the range, while the former is seen farther down the line. Each machine travels on a track which completely surrounds the range of retorts. It carries its own steam boiler and engines for moving the machine down the front of the retorts and performing the various operations of charging and discharging. At the top of the discharging machine is a hopper capable of carrying six tons of coal, or sufficient to charge the whole line of retorts on one side. Below the hopper and placed vertically below one another, are three automatic scoops which are arranged at heights corresponding to the level of the three tiers of retorts. The scoops are rectangular in section and of such length and capacity as to contain the proper amount of coal for charging the retorts. They are loaded by gravity from the hopper and are thrust simultaneously into the retorts, where, by means of a very ingeniously contrived mechanism, the scoops are withdrawn, leaving their charge of coal behind. As soon as the retorts are charged, they are closed by means of special self-sealing doors, and the charger is moved forward by its own engine to a position in front of the next series. The carbonization of the coal usually takes about four hours, at the end of which time the gases have been completely driven off, leaving practically pure coke behind. The lid of the retort is then opened and the coke is withdrawn by means of the discharger, which is driven up into position on the railway. This discharger is very similar in construction and operation to the charging machine. It has three long rakes arranged vertically, one above the other, at an elevation corresponding to that of the retorts. The rakes are thrust into the furnace and withdrawn by means of a steam cylinder 8 inches in diameter by 3 feet stroke operating a rack and endless chain and a drum. The rake is lifted as it enters the retort, in order to clear the fuel, dropped as soon as it reaches the back of the retort, and then withdrawn, bringing the charge of coke with it. During the process of distillation there is deposited on the inner surface of the walls of the retort a deposit of carbon known as "scurf," which is utilized in the electrical industries. Once in every six weeks it is necessary to burn out this deposit by means of air and steam until it is sufficiently thin to be broken with chisels and withdrawn.

The gas produced by the carbonization of the coal leaves the retorts by means of vertical ascension pipes, by which it is conveyed into a large horizontal half-round pipe known as the hydraulic main, which runs the whole length of the range, as shown in the engraving. The ascension pipes terminate in what are known as dip pipes, which descend a few inches below the surface of the collection of tar and ammoniacal liquor that fills the half-round bottom of the hydraulic main. The liquor is kept at a predetermined level by means of an adjustable overflow, which is shown just to the right of the hydraulic main. The gas enters the main through the dip pipe, bubbles through the liquid, and escapes from the main by means of a large pipe which conveys it to the condensers. The object of the dip pipe is to provide a seal which will prevent the return of any gas to the retorts. The tar and ammoniacal liquor, as they accumulate in the main, flow to the adjustable valve and are conducted through a trap to what is known as the tar and ammoniacal liquor well.

The condensers, which are shown in our engravings to the right of the retorts, are two in number. Each consists of a huge cast iron box 22 feet in height, 45 feet in length, and 6 feet in width, which is filled with a mass of vertical 4-inch tubes which extend between two tube sheets arranged a few feet from the bottom and from the top of the condensers, as shown in our sketch. Circulating water is kept continually flowing around the tubes, while the gases from the retorts are made to travel alternately up and down through the tubes until they have traversed the whole length of the condensers. The tubes are divided into groups of fifty-four, there being eighteeen groups in each condenser. The gas enters at the bottom of the first group, passes up through it to the top of the next group, down through that group, then up through the next, and so on, until the series has been traversed. The gas enters at a temperature of between 110 and 115 degrees at one end, while the circulating water enters at 70 degrees at the opposite end, the gas finally leaving at 70 degrees, while the water escapes at the original temperature of the gas, of from 110 to 115 degrees. The cooling of the gas causes the vapors of the various hydrocarbons and the aqueous matter distilled from the coal to condense in the liquid form. We have seen that much of the heavy tar and some of the weak ammoniacal liquor was deposited in the hydraulic main, and the further cooling which takes place in the condensers results in the condensing of most of the strong ammoniacal liquor and some of the light tar. These liquid products collect at the bottom of the condensers, flow out along the bottom of the inlet pipe from the retorts, pass through a trap, and finally collect in the tar and ammoniacal well before referred to, In the two condensers there is a total cooling surface of 18,000 square feet.

At the opposite end from which it entered, the gas is led from the condensers by a large main and passes through what are known as the exhausters. Of these there are three at the Fourteenth Street works, two of which are constantly at work, the other being in reserve. The exhausters are simple Roots blowers, which serve to draw the gas through the condensers from the retorts and force it through the scrubbers and purifiers on its way to the holders. The exhauster, one of which is shown in our engraving immediately in front of the condenser, performs the double duty of relieving the pressure in the retorts, and producing the proper pressure in the holders for distribution through the city mains. The pressure in the retorts is maintained at about 1 inch of water, while the pressure in the holder is maintained at 7 inches.

From the exhausters the gas is forced through a large valve into the bottom of two huge circular towers technically known as "scrubbers." The scrubbers are in duplicate, and the following description of one will apply fully to the other. The tower, which is built of sheet iron, consists of an inner and an outer shell, this construction being adopted to guard against freezing in severe winter weather. The diameter of the inner shell is 13 feet, and its height to the platform is 62 feet, the total height of the structure over all being 84 feet. Down through the vertical axis of the tower extends a large 24-inch pipe for the return of the gas after it has ascended to the top of the tower. The space between the 24-inch main and the outer shell is filled with a vast number of slats of wood ¼ of an inch in thickness and 6 inches in depth. These are carried vertically on a series of superimposed radial arms, the object being to provide the largest possible amount of surface consistent with leaving sufficient space for the upward passage of the gas. At the top of the mass of slats is what is known as a "distributer," which consists of a rotating arm which extends entirely across the scrubber and is fed with a constant stream of water, which, as the arm rotates, is sprinkled evenly over the mass of slats below. The effect of this constant sprinkling is to keep the whole surface of the innumerable slats that fill the tower constantly wet, with the result that as the gas passes up through the slats it is thrown into intimate and thorough contact with the water and the ammonia gases are completely absorbed and carried down to the base of the tower, where they pass off through a trap to the ammonia well.

After leaving the scrubbers the gas is conducted through a large valve shown in the engravings to a series of purifiers, where whatever carbonic acid and sulphureted hydrogen remains is abstracted, together with some of the sulphur compounds. The carbonic acid must be removed, because it would lessen the illuminating strength of the gas, while the sulphureted hydrogen, for obvious reasons, must be completely taken out also. The purifiers measure 24 by 26 feet and 4 feet in depth. They contain a number of superimposed trays which are filled with oxide of iron and lime, the oxide of iron serving to remove the sulphur and the lime the carbonic acid. The gas is introduced at the bottom of the purifiers and passes up through the trays, finally leaving by way of the center seal valve, shown in the engravings. From this valve it is conducted to large water meters 15 feet in diameter and 12 feet in length, where its amount is registered. From the meters it passes underground through a main extending vertically into the center of the gas holder and terminating a few feet above the water level.

The gas holder, which not long ago was the largest of its kind in the country, is a huge affair 194 feet 6 inches in diameter and 165 feet in height when it is raised to its full lift. It is of the three-lift, telescopic type, and when it is down the whole of it telescopes into a large water-tank 42 feet in height, whose foundations are laid several feet below the surface of the ground. This tank has a capacity of 3,300,000 cubic feet. Huge as it is, however, it will be seen that it is by no means equal to accommodating the maximum output of the station, which, when everything is in full blast, amounts to 5,000,000 cubic feet per day.

In closing, it should be mentioned that the weight of the holder is not raised, as is often popularly supposed, by the lifting power of the gas, but by the actual pressure produced direct from the exhauster already referred to. This pressure is equal to about seven inches of water. The gas is led to the mains by the vertical pipe shown adjacent to the main by which the gas enters the holder. Before being delivered to the mains, however, the pressure is reduced to 3 inches for night consumption and 2 inches for day service.

(To be continued.)

## THE TECHNOLOGY AND USES OF PEAT.*

By C. W. PARMELEE.

THE uses of peat grouped according to the origin of the properties may be given as follows:

I. Those due to its chemical composition:
   A. Carbon and hydrogen content—
      1. Directly as a fuel, raw or manufactured.
      2. Coked, the products are: Coke, gas, ammonia, acetic acid, methyl alcohol, tar.
      3. Gas.
   B. Nitrogen content, chiefly in agriculture.

II. Those due to its physical nature:
   1. As a fibrous material: For litter, for textiles, for paper stock.
   2. As an absorbent.
   3. As a non-conductor of heat and sound.

III. Those due to its chemical-physical nature:
   As a preservative.

### PEAT AS A FUEL.

*Use in Europe.*—The chief value of peat undoubtedly depends upon its content of combustible matter. For economic reasons this has had little recognition in this country, and we probably use more as litter than for any other purpose. In all parts of northern Europe, of Ireland and Scotland, wherever the climate is cold and damp and firewood scarce or unobtainable and peat available, it has been the ordinary domestic fuel since prehistoric times. The consumption must have steadily increased up to the time that the introduction of railroads made coal a vigorous competitor. Since then, however, the production has continued steadily, as the following figures show. According to a report of a British commission, made in 1893,[1] the Netherlands consumed 280,000 tons annually in the burning of brick. A writer in the Journal of the Royal Agricultural Society, 1893, states that it is estimated that 150,000 tons are annually used for household purposes in the Grand Duchy of Oldenburg. In the year 1890 Bavaria was said to use annually 60,000 tons as fuel for railway locomotives. According to a report made by the Russian government for the Chicago Exposition of 1893,[2] it is stated that in 1890 peat was used as a fuel in that country in the following industries: Cotton manufactures, 537,000 tons; sugar factories, distilleries, confectioners, flour mills, and macaroni factories, 70,000 tons; manufacture of chemicals, 5,000 tons; candle, tallow, and leather trades, 4,000 tons; woodworking, 1,000 tons; metal manufactures, 60,000 tons; glass works, 80,000 tons; paper manufactories and miscellaneous, 2,000 tons; an aggregate of 772,000 tons. Engineer Alf Larsson, in an address delivered at Stockholm[3] in 1902, said that Russia produces yearly 4,000,000 tons of peat, and the Russian government receives annually $938,000 for leasing bogs. Germany produces 2,000,000 tons annually; Holland, 1,000,000; Sweden, 1,000,000 tons.

We can readily understand the above figures if we bear in mind the following facts regarding European conditions, namely, peat has always been recognized as

* Abstracted from the annual report of the State Geologist of New Jersey.

[1] Report of H. M. Representatives on the Manufacture of Fuel, Moss Litter and other Products of Peat in European Countries, Blue Book Commercial, No. 2, 1893.

[2] Journal of the Society of Chemical Industry, vol. 13, p. 596.

[3] Special U. S. Consular Report, xxvi, p. 125.

a fuel; that the fuel resources are limited and the inhabitants are accustomed to utilize as combustibles all available materials, even burning grass and straw in their brick kilns.

*Use in America.*—In our country there have been a few scattered attempts to use peat as a fuel. These experiments have been of short duration and at present there are few persons, probably, who are sufficiently familiar with peat to recognize it or know how to prepare it for use. The early settlers of Massachusetts brought the old world practice, which, however, did not flourish where wood could be had merely for the labor of cutting. On Martha's Vineyard and Nantucket Islands, the descendants of the Indian inhabitants still continue the practice because of the lack of other cheap fuel. According to Dr. George H. Cook,[4] peat was "long used in Chatham Township, Morris County, and to a smaller extent in many other places." Attempts to manufacture fuel with the use of machinery were made at Belleville, Essex County, and at Allendale, Bergen County. A plant was also projected at Beaverton, Morris County. The industry did not flourish, however, either here or in New England, where similar attempts were made.

*Water Content.*—Since peat is formed by the partial decay of vegetation at the place of its growth, we find a considerable difference between the top and bottom of such deposits. At the surface there are the growing plants, next the dead growth, then a fibrous partially decayed mass, and finally a waxy peat in which all the fiber has disappeared. These layers have different properties and, if extensive, may be separately used for various purposes. Sometimes there may be differences in various sections of the same bog. The whole mass is thoroughly wet like a sponge, as this is a necessary condition for its growth. This water content in a freshly-cut sample may be as high as 85 per cent or 90 per cent. When the peat is cut and removed from the bog, it loses a great part of this water content, but never dries out entirely. It still retains a considerable portion, which may vary with the condition of the atmosphere and character of the peat. This water content in a good air-dried peat should not exceed 25 per cent.

*Ash.*—Peat always contains some mineral matter which has been part of the plant structure or has accumulated through a variety of natural causes. The lower part of the bog contains the greater quantity, and it may vary in different sections of the same bog. This mineral matter we determine and describe as the ash content. It has a very important place in determining the probable usefulness of the peat. If the amount is greater than 50 per cent, the material may be better described as muck, rather than peat. Twenty-five per cent is the maximum quantity permissible in a fuel peat, and 5 per cent is low.

The practical importance of the amount of ash is readily apparent when we consider that with every additional unit of inorganic matter we increase the cost of digging and transporting the peat, and not only lose in burning the use of the combustible material displaced, but also a certain amount of heat which is required to bring the non-combustible matter to the temperature of the fire and maintain the temperature at that point. Fortunately, the ash is very light and powdery. It does not clinker the grate bars, and they are said to last much longer than with coal firing.

The chemical composition of the ash is given by Thenius[5] as follows:

"Silica, which is mechanically mixed with the peat, varies from 15 per cent to 30 per cent, according to the character of the adjacent soil.

"Lime, occurring partly as the sulphate, partly as the carbonate in very notable quantities as much as 20 per cent or even 30 per cent.

"Magnesia is present in almost all peats, varying from 1 per cent to 10 per cent.

"Alumina occurs sometimes in large quantities, sometimes in small. It varies between 2 per cent and 5 per cent.

"Ferric oxide gives the ash its red color. Often found in notable quantities.

"Phosphoric acid is present in many peats, yet seldom over 2.5 per cent.

"Alkalies occur only in small amounts, reaching at the highest 2 per cent to 3 per cent."

Dr. S. W. Johnson[6] gives the following results as the average of his investigations of the ash of American peats:

| | *Average.* | *Minimum.* | *Maximum.* |
|---|---|---|---|
| Potash, | 0.89% | 0.05 | 3.64 |
| Soda, | 0.83% | None | 5.73 |
| Lime, | 24.00% | 4.72 | 58.38 |
| Magnesia, | 3.20% | None | 24.39 |
| Alumina, | 5.78% | 0.90 | 20.50 |
| Ferric oxide, | 18.70% | None | 73.33 |
| Sulphuric acid, | 7.50% | None | 37.40 |
| Chlorine, | 0.60% | None | 6.50 |
| Phosphoric acid, | 2.56% | None | 6.29 |
| Sand, | 25.50% | 0.99 | 56.97 |

The ashes are said to be of value as a fertilizer, which explains in part the good results following the cultivation of burned moorland, a practice which has had a considerable vogue in Europe.

The composition of ash-free and dry peat is given by two writers as follows:

| | *Hausding.* | *Websky.* |
|---|---|---|
| Carbon, | 60% | 49.6% to 63.9% |
| Hydrogen, | 5% | 4.7% 6.8% |
| Oxygen, | 34% | 28.6% 44.1% |
| Nitrogen, | .... | 0.0 2.6% |

*Relation to Other Fuels.*—The relation of peat to various fuels is shown in the following table, which also very well illustrates the progressive changes peat might undergo in a possible conversion to anthracite. According to Ost:[7]

| | *Wood.* | *Peat.* | *Lignite.* | *Bituminous Coal.* | *Anthracite Coal.* |
|---|---|---|---|---|---|
| Carbon, ..... | 50% | 60% | 70% | 82% | 94% |
| Hydrogen, ... | 6 | 6 | 5 | 5 | 3 |
| Oxygen, ..... | 43 | 32 | 24 | 12 | 3 |
| Nitrogen, .... | 1 | 2 | 1 | 1 | trace |

*Calorimetric Tests.*—The value of any fuel depends upon the quantity of heat generated and the temperature which can be obtained. The determination of the quantity of heat a fuel can furnish is called the calorimetric test, and the results furnish a very accurate means of comparison of the relative value of different kinds of combustibles. Chemical analysis of fuels will show how they differ in composition, but it does not furnish satisfactory data showing how they actually compare in heating power. The unit of heat which we use in reporting the results may be the calorie or the British thermal unit (B. T. U.). The calorie is the amount of heat necessary to raise 1 kilogramme of water 1 deg. C. The British thermal unit is the amount of heat necessary to raise 1 pound of water 1 deg. F. British thermal units may be converted into calories by multiplying by 5/9.

*Effects of Ash and Moisture on Heating Power.*—The influence of the amount of moisture and ash upon the heating power of peat is very well shown in the following table, according to Hausding:[8]

| | *Calories.* |
|---|---|
| Dry peat without ash, | 6,500 |
| " " with 4% ash, | 6,300 |
| " " " 12% " | 5,800 |
| " " " 30% " | 4,500 |
| Same peat with 25% water, | 4,700 |
| " " " 30% " | 4,100 |
| " " " 50% " | 2,700 |
| " " " 0 " 15% ash, | 5,500 |
| " " " 25% " 0 " | 4,700 |
| " " " 30% " 10% " | 3,700 |

It will be noticed upon comparison of the above figures that the difference between two samples of peat having a different content of moisture is greater than that due merely to the displacement of combustible matter. For example, dry peat has the value of 6,500. That containing 25 per cent water is not 75 per cent of 6,500, which would be 4,875, but according to the table it is 4,700. The explanation for this difference is that the loss represents the amount of heat consumed in vaporizing the moisture. This very well illustrates the necessity of preparing peat for use so as to contain as little content of moisture as practicable, and in such a form as to be little affected by atmospheric moisture.

*Heating Power of Peat and Other Fuels.*—The following table gives a comparison of various fuels:[9]

| | *Water Chemically Combined. Per cent.* | *Water Mechanically Held. Per cent.* | *Ash. Per cent.* | *Calories* |
|---|---|---|---|---|
| Wood, air dry, | 30 | 20 | 1 | 3,232 |
| " kiln dry, | 49 | 0 | 1 | 4,040 |
| Charcoal, air dry, | 0 | 12 | 3 | 6,868 |
| " dry, | .. | .. | 3 | 7,837 |
| Anthracite coal, | 2 | 3 | 2 | 8,305 |
| Peat, | 25 | 25 | 5 | 3,959 |
| " manufactured, | 30.4 | 18 | 3 | 4,439 |

The calorific value of fuels furnishes the data for their comparison, but in practical operations it is not possible to realize the full value owing to such causes as imperfect combustion, radiation losses, etc. The useful heating power may be compared in terms of work accomplished under practical conditions. The following claims have been made for peat:[10]

One pound of pressed peat will vaporize 5 to 6 pounds of water in a boiler.

Two hundred and fifty pounds will melt 100 pounds of glass batch.

Six to seven hundredweight is required to burn 1,000 brick.

One hundred pounds is required to burn 80 to 100 pounds of lime.

According to Hausding,[11]

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | Kilogram | of air-dried wood | will evaporate | 3 to 3.4 | Kilograms | of water. |
| 1 | " | " hand-cut peat | " " | 2.8 " 4 | " | " " |
| 1 | " | " machine | " " | 4.5 " 5 | " | " " |
| 1 | " | " best coal | " " | 7 " 8 | " | " " |

Roberts-Austin says that "for equal evaporative power its (peat) bulk is eight to eighteen times that of coal." This probably has reference to the most bulky form of peat, namely, hand-cut peat.

Peat burns with the evolution of a large quantity of volatile, inflammable gases and an empyreumatic odor, which is agreeable to many persons. The evolution of these gases makes it a very particularly desirable fuel for some purposes as, for example, the ceramic industries. On the other hand, this large volume of gas requires greater flue space. This increase in size over that used in coal firing will vary[12] from 8 per cent to 27 per cent, depending upon the temperature of the gases. Attention must also be paid to the character and size of the fire mouth and grate. Dense peats do not require the same large grate area as the looser varieties.

(To be continued.)

[4] New Jersey Geological Survey, 1868, p. 13.
[5] Werwertung des Torfes, Berlin, 1904, p. 160.
[6] Peat and Its Uses. N. Y., 1868, p. 48.
[7] Technische Chemie, Hanover, 1903, p. 12.
[8] Handbuch der Torfgewinnung, Berlin, 1904, p. 339.
[9] Hausding, Handbuch der Torfgewinnung, Berlin, 1904, p. 328.
[10] Journal of the Society of Chemical Industry, 1899, p. 1113.
[11] Handbuch der Torfindustrie, p. 335.

## SPECIAL STEELS FOR AUTOMOBILE CONSTRUCTION.

PROBABLY no other industry has exerted such an influence on the metallurgy of special steel as the motor car industry, says the Iron and Coal Trades Review. Apart from the development of this industry within the past few years, the main factors that have contributed to this influence are the difference between the cost and the selling price, the responsibility of the makers, the extremely high strain put on the material, and the necessity of lightness of construction. The car builders have on this account to adopt a high standard in their specifications for the raw material, and have, as a rule, adopted all the precautions that the newest developments in metallurgy have placed at their disposal.

Motor car builders have seven different kinds of steel in use—nickel steel, low in nickel and carbon, for parts subjected to great friction and little shock; steel with a low nickel and medium carbon content, for shafts, axles, and bearing cups; steel, high in nickel and low in carbon, for valves, owing to the low expansion of this grade under changes of temperature; chrome steel, high in carbon and low in chromium; silicon steel, with varying proportions of silicon and carbon, for springs and pinions; chromium-nickel steel, low in nickel and chromium, for parts requiring a fairly hard metal with high resistance to shock; and the new steel, of unknown composition, sold as N Y steel.

These steels may be divided into two chief classes, namely, such as contain one, and such as contain more than one, added ingredient in addition to iron and carbon, the former represented by the nickel, chrome and silicon steels and the latter by chromium nickel steel and varieties whose composition is kept secret by their makers.

*Nickel Steels.*—Although nickel steel may be subdivided into three categories according as the proportion of nickel is low, medium or high, the best method of classifying it is as follows, showing not merely the proportion of nickel alone, but also the sum of the nickel and carbon:

1. Low in nickel (1 to 6 per cent) and very low in carbon (0.10 to 0.25 per cent).
2. Low in nickel (1 to 6 per cent) with medium carbon (0.25 to 0.40 per cent).
3. Medium nickel (10 to 18 per cent) and medium carbon (0.20 to 0.25 per cent).
4. High in nickel (30 to 36 per cent) and low in carbon (0.12 to 0.20 per cent).
5. High in nickel (20 to 30 per cent) and high in carbon (0.60 to 0.80 per cent).

Experiments have shown that nickel steel with 2 per cent of nickel has the minimum degree of fragility, while by a single hardening at 800 deg. C. it gives results as good as those furnished by double hardening ordinary carbon steel.

Steel with a low carbon and nickel content is now generally used in motor-car work, the usual proportions being: Carbon, 0.10 to 0.15 per cent, and nickel, 1.5 to 2 per cent; but for the axles, shafts, bearing cups, valves, etc., various other proportions are used. The micro-structure of the steel is also an important feature in the selection of the most suitable material for the different parts according to the friction or strains they have to stand.

The chrome steel used usually contains 1 to 1.5 per cent carbon and 1 to 2.5 per cent chromium, and before use is hardened by tempering once, at 800 deg. C. in oil and then at 850 deg. C. in water, this treatment obviating the formation of the cracks formed when water alone is used.

Silicon steel, or manganese-silicon steel is used largely for pinions and springs. The composition varies between the limits of 0.30 to 0.70 per cent carbon, 2.5 to 0.80 per cent silicon, and 0.35 to 0.50 per cent manganese, the proportions of carbon and silicon varying inversely. Its extensive use for pinions is due to the fact that, when properly treated, the outer skin is rendered hard enough to prevent the metal spreading and because the fragility cannot be very great in the case of forgings.

Tungsten steel has been tried as a substitute for silicon steel in the manufacture of springs, but without any great success, the greater strength crosswise of the fiber being hardly compensated by the loss in longitudinal strength and the higher price. The average composition is: Carbon, 0.47 per cent; manganese, 0.22 per cent; tungsten, 0.6 per cent.

Vanadium steel has been extensively used in Great Britain.

Chromium-nickel steel is very largely used, possessing all the advantages of nickel steel, together with the increased hardness imparted by the chromium, a very important quality for parts exposed to much friction, such as pinions and axles. There are in use four grades of this steel whose compositions are given, and one other grade, sold on the market under the mark N Y, the composition of which is not disclosed, which is generally used for making pinions.

This article referred to gives much detail and data

[12] Bache, Proceedings of the Institute of Civil Engineers, 1900-1, vol. cxlvi, pt. iv.

regarding micro-structure of nickel steels, the temperatures required for annealing, tempering, and case-hardening, and of tensile strength, elastic limit and elongation of the different classes.

## CORN-HARVESTING MACHINERY.*

By C. J. C. ZINTHEO.

CORN was the earliest as it is the most important cultivated crop on the American farm. When the first colonists settled on American soil they found the Indians producing corn, and also preparing various foods

FIG. 1.—CORN HOOK.

from it. The first corn grown by white men was that of the Virginia Colony, at Jamestown, in 1608, and it is claimed that two Indians taught them how to plant and cultivate the crop. The product of this harvest served almost as the sole food supply of the colony. The early Massachusetts colonists, too, received their first lessons in corn cultivation from the Indians. The first fields cultivated by the settlers there were those which had been left vacant by the Indians.

The United States census of 1840 gives the corn yield for that year as 377,518,875 bushels. The following census (1850) places the yield at 592,000,000 bush-

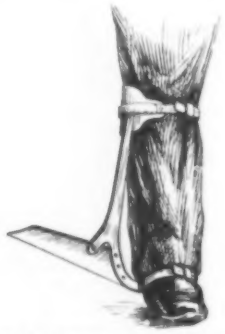


FIG. 2.—FOOT DEVICE FOR CUTTING CORN.

els, with a corn acreage of 31,000,000. During the civil war little advance was made in the production of corn. In the year 1900 the United States alone produced 2,105,102,516 bushels, or about 75 per cent of the total crop of the world. In 1904 the yield of corn reached 2,467,480,934 bushels, and the acreage 92,231,581.†

There may be, moreover, a double harvest from every field of corn—that of the grain and that of the fodder. There are thousands of farmers in the United States who in the last few years have doubled the profit they used to make on their corn crop, by harvesting the whole plant—stalks, leaves, and all—yet there are tens of thousands of other farmers who still "snap" or husk their corn in the field, letting the stalks and blades go largely to waste. It has been demonstrated beyond a doubt that when properly harvested corn fodder is as nutritious as good hay. The farmer who would receive the full value of his crop

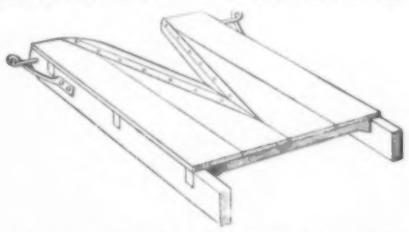


FIG. 3.—ONE-ROW SLED HARVESTER.

should secure this fodder with as much care as he gives his hay, taking care that it is harvested at the proper period, and not allowed to have the nutrients it contains leached out by rains or injured by frost.

The composition of the dry matter of the fodder corn varies greatly with the season. The yield of food material increases with the advancing age of the corn, the largest amount being obtained when the corn is well ripened. Feeding experiments have been conducted with corn fodder by which it has been determined that at least 45 per cent of the food value of the corn plant is in the stalk, and that the stalk can be cut at the time the ear is dented without material loss to the kernel. A mine of wealth is thus opened to those farmers who are in position to make use of this fodder.

For years we have had machines which successfully harvest, thresh, and clean the small grains, so that every part of the plants may serve some useful purpose. The machinery for the care of the corn crop has been much more difficult to develop than any other line of farm implements. Although there has been considerable progress in the harvesting of corn, no such profound changes have been made as those in the harvesting of small grain. The larger part of the crop is still husked by hand from the standing plant, and the crop is but partially utilized. In large sections of the country only the ears are gathered, while the leaves and stalks are almost a total loss.

After the success of mowing and reaping machines, inventors tried to develop a corn harvester along the lines followed in the construction of those machines. The old methods of harvesting corn fodder were slow, expensive, and laborious, and the manufacturers have long sought to solve the problem. Their success is not as yet complete, but the labor-saving devices so far

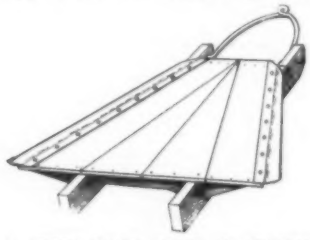


FIG. 4.—TWO-ROW SLED HARVESTER.

perfected have largely changed conditions. The corn may now be cut, husked, and shredded with less labor than the cutting alone formerly required.

### SIMPLE METHODS OF HARVESTING CORN.

*Topping.*

As a stock food, both the ears and the stalk of the corn plant have been used from the earliest times. The Aztecs and the Peruvian Indian tribes practised topping corn for this purpose at the time they were conquered by the Spaniards. This method of securing fodder was followed by the early colonists and continued to be the common method until late in the nineteenth century. It is largely followed in Italy, and is still practised in many parts of the South.

Before topping corn, it is necessary to allow the ears to pass the silking period in order to secure fertilization. If done before this, the grain fails to develop. Soon after fertilization has been accomplished the silk rapidly turns brown, and when the kernels have passed the milky state the corn plant is ready to top.

The topping was formerly done by a man who, with a sharp knife, passed along the row of corn and cut off the top just above the ear, and also stripped the leaves from that part of the stalk left standing in the field. The parts cut off were laid in small piles to dry and were afterward tied into bundles. The bundles were set up in little shocks and left until the fodder

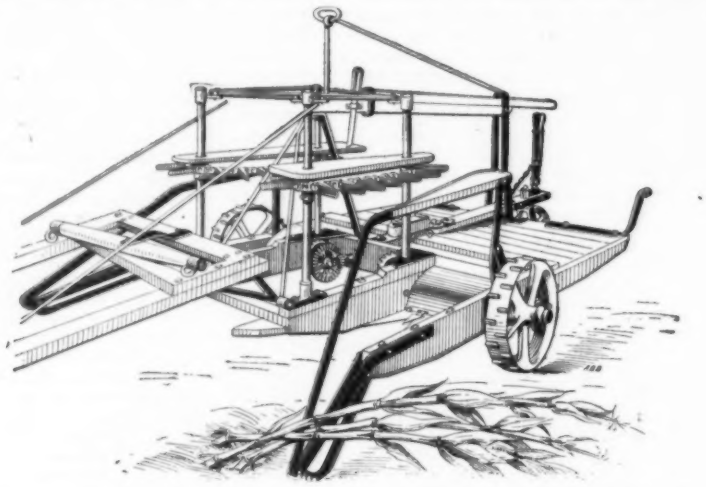


FIG. 6.—TWO-ROW CORN HARVESTER WITH STATIONARY LIFT.

was sufficiently cured, when they were hauled away and stacked near the feeding place. This feed was considered very valuable and was used for feeding the horses and oxen in the spring before the grass came, when the work animals had the hardest labor of the year to perform.

In regard to the advisability of topping corn, the Pennsylvania Station* found that, by topping, 1,050 pounds of fodder was obtained, at a loss of 540 pounds

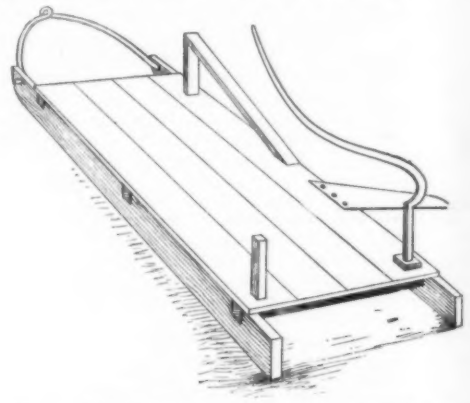


FIG. 5.—IMPROVED ONE-ROW HARVESTER.

of ear corn, as compared with allowing the corn to ripen and merely gathering the ears. The Mississippi Station,† as a result of a three years' trial, found the net loss in feeding value more than 20 per cent. Seven other stations show an average loss which was "more than the feeding value of the fodder secured."

*Corn Cutting With Knives.*

The unsatisfactory results which followed when corn was topped or stripped, together with the extension of corn growing, led the farmers to seek a better way of securing fodder. This was found in the method, continued to our own time, of cutting the stalk close to the ground at a time when no damage is done to the ripening grain and while, at the same time, considerable of the saccharine juices still remain in the stalk.

The implement first used for corn cutting was the hoe, or something akin to it, and it continued to be

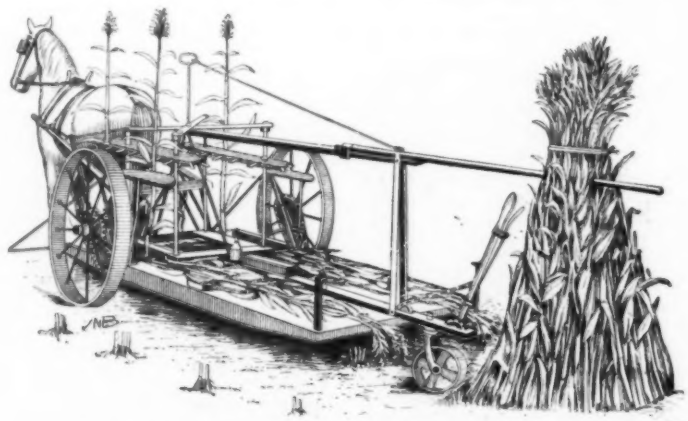


FIG. 7.—REAR VIEW OF TWO-ROW CORN HARVESTER.

* Abstracted from a bulletin issued by the Office of Experiment Stations, United States Department of Agriculture.

† United States Department of Agriculture Yearbook, 1906, p. 628.

* Pennsylvania Station Report, 1891, pp. 55-60.

† Mississippi Station Bulletin 33, p. 64.

used as late as the beginning of the nineteenth century. This was rather heavy and awkward to handle and the work of harvesting was slow and exhausting. The more progressive farmers discarded this crude implement and substituted the corn knife.

Many kinds of blades were used for the purpose, but among them the scythe blade was most largely employed. It was customary to cut these blades in two parts. The knife made from the point of the scythe was considered the better. It was somewhat lighter in weight than that made from the shank end, and of better shape. Sometimes a shank was made by beating and hammering the upper end of the blade into proper shape, and sometimes by cutting away the thin part of the blade for a few inches. By many these old home-made knives are much preferred to the factory-made knife now almost universally used. The factory-made knives are of all sizes and shapes. The corn hook (Fig. 1) now extensively used is generally considered even more convenient than the corn knife.

In Fig. 2 is shown a form of corn cutter which is fastened to the boot. This implement is pushed with considerable force against the stalks, severing them close to the ground. It is unnecessary to stoop over the work when using it. Another form of this implement is made so as to be fastened to the forearm. This form is very convenient for topping.

When the corn is cut with a corn knife, it is customary to set it up in shocks to cure. Shocks vary greatly in size, ranging from six hills square (thirty-six hills to the shock) to sixteen hills square (256 hills); a very common size is twelve hills square (144 hills). Shocks of the smaller sizes are common in the North Atlantic States, where, according to the Connecticut Station, it is more difficult to preserve flint-corn stover; while ten hills square and twelve hills square are common in the North Central States.

After the fodder has become cured, which usually takes about a month, the shocks are generally husked by hand in the field, and the stover is commonly tied into bundles, though this is by no means a universal practice. The stover is then shocked up again. Frequently the stover from two or more shocks of corn is put up in a single shock. For convenience in husking a movable table is sometimes used, on which the stalks are laid while being husked. The ears are thrown in piles on the ground near the shocks, and afterward hauled to the crib. The stover is sometimes hauled to the barn and stored, but often it is left standing in the field till needed for feeding during the winter.

It is important to choose suitable weather conditions for husking, since if the plants are too dry the stalks will break and blades will fall off and be lost. On the other hand extremely wet weather makes the ground too soft for hauling in the corn.

The cost of these methods of caring for the corn crop varies with the locality and the year. Taking the average of the replies to 200 inquiries, it has been learned that one man is able to cut and shock by hand about thirty-four shocks twelve hills square, or nearly 1½ acres of corn per day. The average cost per shock for cutting by hand is 6.5 cents, or $1.50 per acre.

Results of Harvesting Corn by Different Methods.

| How Harvested. | Shelled Corn. | Blade Fodder. | Stover. | Total Value of Product per Acre. |
|---|---|---|---|---|
| | Bushels | Lbs. | Lbs. | |
| 1. Blades pulled; stalks harvested. . . . | 47.24 | 585 | 2,012 | $35.18 |
| 2. Blades pulled; stalks not harvested.. | 47.24 | 585 | ..... | 27.13 |
| 3. Stalks cut and shocked. | 48.74 | .... | 3,067 | 39.55 |
| 4. Ears husked and stalks cut when dry. | 45.43 | .... | 2,195 | 31.49 |

The total values are based on the following prices: Shelled corn, 50 cents per bushel; naked, weather-beaten stalks and husks shredded, 40 cents per hundredweight; the stover, including stalks, blades, and shucks from the shocks, 50 cents per hundredweight; cured corn blades, 60 cents per hundredweight.

The plats on which the stalks were cut and shocked yielded 1.5 bushels more than plats on which blades were pulled, and 3.31* bushels per acre more than the plats on which the stalks were left untouched.

MACHINES FOR HARVESTING CORN.

*Sled Harvesters and Similar Devices.*

As early as the year 1820 attempts were made to construct a mechanical corn harvester. From that year until 1892 all attempts to perfect such a machine were unsuccessful. The machines invented were patterned after the mower and the reaper, but owing to the size of the corn plant these machines either would not cut at all or were soon broken under the heavy strain. Some of the machines, however, had commendable mechanical features which were embodied in machines invented later.

Many home-made harvesting devices of the sled pattern have been made from time to time, some of which are illustrated in Figs. 3, 4, and 5. The first harvester of this class was patented by J. C. Peterson, of West Mansfield, Ohio, who put one in the field in 1886. Others followed and added improvements until eight or ten harvesters of this kind were in the field.

With most of the sled harvesters the driver rode on the platform, and it was necessary for him to gather the stalks in his arms in advance of the cutting edge, so as to prevent them from falling in various directions. This method of harvesting was very exhausting. The harvester shown in Fig. 6 was an improvement, in that the guiding arm collected the stalks on the platform and it was only necessary for the driver to pick the stalks from the sled at intervals and throw them on the ground. As an improvement, in order to reduce the draft, the sled was mounted on wheels. This machine cuts two rows at a time, and two men sit on the platform, one facing each row, to guide the corn against the cutting edge with one hand, and with the other hand and arm to collect the cut corn on the tilting-side part or wing of the platform, drawing it back against the leg, where it is assembled until enough has been collected to form a shock. The stalks are then tied together into a small shock, and the side platform is so tilted as to deposit it upon the ground in an upright position. This form of corn harvester is still used quite extensively. It has automatic knife guards by which the cutting edge of the knife is covered with a plate of steel when the machine is not in use. This lessens the danger of injury to men and animals, which often happens when the cutting blades are left exposed. The tilting parts or wings of the platform may be raised into a vertical position to pass obstructions, or may be folded back against the seat standard. The wheels can be adjusted to cut corn high or low.

To reduce the labor involved in cutting corn with the machines described, another form of corn harvester was invented, as shown in Figs. 6 and 7. This machine consists of two driving wheels, between which is mounted the frame for the driving mechanism and platform. It is drawn by one horse, which walks between the two rows that are cut at the same time. The dividers pick up the lodged corn, except such as lies in the row of corn away from the machine, and guide it to the cutting apparatus, which consists of two stationary side blades, above which is a movable sickle, which cuts the corn and deposits it horizontally on a platform that is elevated about six inches above the cutting apparatus. On the inner side is a guide chain, which assists in directing the stalks of corn to the knife and the platform.

The sled harvesters and corn harvesters of the same type vary in price from $5 for the simpler forms, which are made at home by the farmer, to $55 for the more elaborate machines as shown in Figs. 6 and 7. These harvesters have one great advantage over the more complicated machines in that the first cost is low. For this reason every farmer, even with only a few acres of corn to cut, can afford to have one. It requires but one horse for motive power, and very little if any twine is used to tie the shocks. However, if the corn is tangled or lodged the cruder forms of

FIG. 8.—AN EARLY CORN HARVESTER.

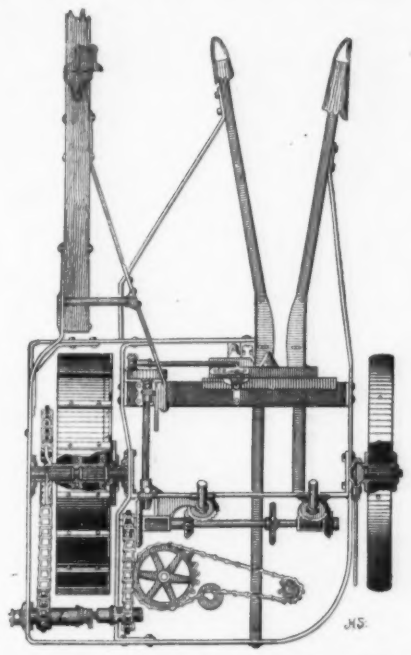


FIG. 11.—FRAME OF CORN BINDER, SHOWING MECHANISM FOR DRIVING CUTTER KNIFE, GEAR SHAFT FOR DRIVING CHAINS AND BINDING DEVICE, AND ROLLER BEARINGS.

FIG. 9.—VERTICAL CORN HARVESTER IN THE FIELD.

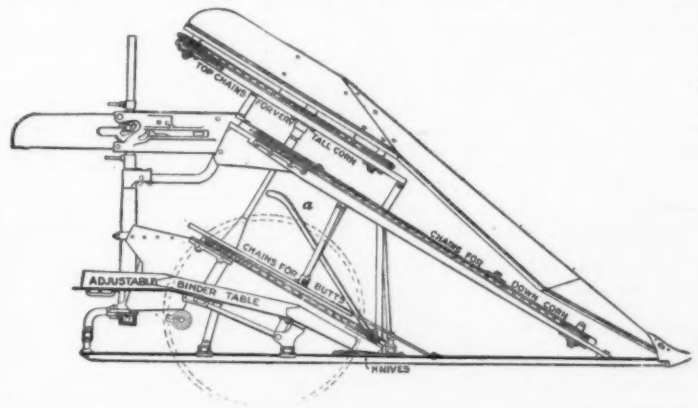



FIG. 10.—SKELETON FRAME OF CORN BINDER, SHOWING CHAINS.

* The larger yield of shelled corn from the plat that was cut and shocked should not be counted in favor of that method of harvesting. It is explained as follows in the Georgia Bulletin just cited: "The increased weight of grain for the plats on which the stalks were cut and shocked can be credited to the fact that the ears left on both the other series of plats were drier, because fully exposed to the sun and wind. The cause of difference was overlooked at the time and until too late to remedy. . . . No gain in the weight of grain from the cut and shocked plats was expected, and the results would have been entirely satisfactory had there been a small loss as the result of cutting down the stalks."—EDITOR.

these harvesters cannot be used, as the corn must stand straight and the horse walk rather fast in order that the harvester may do perfect work. It is also rather hard work for the men to gather and shock the corn. The work of harvesting corn is such that only the best construction can withstand the strain for any great while, and hence these machines are being used less than formerly, even in those sections of the country where they were once extensively introduced.

In regard to the cost of harvesting corn with these machines: From ninety replies received in answer to questions, it was learned that the minimum in acreage of corn cut per day is two acres, and the maximum ten acres. The average from all the replies received equals 4.67 acres of corn which can be cut per day by two men and one horse using the sled harvester.

In reply to the question as to cost per acre for harvesting corn, the minimum price reported was 55 cents per acre and the maximum $2. Taking the average of all the replies received, the cost of harvesting corn with a sled harvester is $1.18 per acre. This is estimated on a basis of 18 cents per acre, or 84 cents per day for the use of the machine and repairs; 4 cents per acre, or 19 cents per day for twine; 58.5 cents per acre, or $2.75 per day for one horse and a man who does part of the shocking; and 37.5 cents per acre, or $1.75 per day for the other shocker. Comparing this cost per acre with that of hand cutting, it will be noted that there is a saving of 32 cents per acre in favor of the machines. It will also be noticed that two men and a horse, with a sled harvester, can cut and shock 4.67 acres per day as against 1.47 acres per day for one man with a knife, which gives a credit of 1.73 acres per day for the work of the horse, or a considerable saving in favor of the machine. The work may thus be done quicker than by hand, which is of importance, as the corn plant should be cut promptly just when it is ripe in order to obtain full benefit of all its nutrients.

*Corn Binders.*

Historical.—The credit of inventing corn-harvesting machinery belongs to Edmund W. Quincy, of Illinois, as he obtained the first patent on a corn-harvesting machine in October, 1850. "Old Father Quincy," as he became well known throughout the country, spent more than forty years of his life in efforts to produce a machine to pick corn, and during most of that time he lived in abject poverty, wandering from place to place pursuing the will-o'-the-wisp of promised assistance, using the money tossed to him as alms to construct his crude machines or to remedy their defects, going for days without food or shelter, faithful to his cherished plan until the end. His machine was essentially a field picker. Many other inventors worked like Quincy, on the idea of a machine to pass over the row and pick the ears from the stalks.

Another form of corn harvester (Fig. 8) was invented in the "eighties." This machine cut the cornstalks and elevated them into a wagon, which was very convenient when the fodder was to be used for ensilage. The elevator could be removed and a binder attachment put on by which the corn was bound into bundles, these being left in the field to cure.

One of the earliest forms of corn harvesters and binders was constructed as a modified form of the grain binder. This machine also was so constructed that for the binder attachment a device might be substituted to elevate the corn into a wagon.

The principle in corn harvesters and binders which was destined to prevail was invented by A. S. Peck, of Geneva, Ill., and patented January 5, 1892. It consisted of a corn harvester with the two dividers passing one on each side of a row of corn, which was cut and carried back in a vertical position to the binder attachment by means of chains and gathering arms. A standard twine binder was used, set in a vertical position so as to receive the stalks and keep them in this position until the bundle was discharged. The horses were hitched behind the machine the same as they are on the header or push binder. The machine is shown in Fig. 9, in operation in the field.

The Peck patent received very little attention at first. It showed very few elements that were new, as the vertical principle of cutting grain had been tried and failed to give satisfaction. It was rather a rearrangement of well-known principles used in harvesting machinery than a new departure. Still it was the collection of these principles in proper form which produced a successful machine. After two years' use by the inventor and a few other persons, its merit was recognized by one of the prominent harvester manufacturers.

In the perfection of farm implements there are usually two stages of development. The first covers the conception of the idea and the making of an implement that does its work satisfactorily in the hands of the inventor. The second stage covers the pioneer efforts to manufacture it and to introduce it into general use. The period from the first invention of the corn-harvesting machine by "Father Quincy" in 1850, until 1895, may be considered as covering the first stage of the development of corn-harvesting machinery, in which many machines were made that would work well in the hands of inventors; but almost half a century was required for the designing and perfecting of these machines so that they might be manufactured for general use. During this time much capital was lost in fruitless efforts.

Since 1895 the self-binding corn harvester has had a considerable sale. In practically all of the corn binders now built the features of the Peck type predominate. Even the most divergent forms still retain the general organization of parts used in the Peck machine.

Construction.—There are three different forms of corn binder, namely, the vertical, the horizontal, and the inclined, the latter being rather a blending of the two preceding types. These machines differ only in the relative position of their elements, being composed of the same essential parts. Binders consist essentially of the dividers, of which previous mention has been made, and of cutting and binding devices. (See Figs. 10 and 11.) A bundle carrier is usually attached, but this is not essential to the smooth operation of the machine.

Dividers.—The dividers consist of two diverging jaws opening at the front of the machine. The jaws begin in two points at the front, but gradually widen vertically to where they join the frame of the machine, when they have a width, or rather a height, of 4 feet or more. By an arrangement of levers the points may be raised or lowered. Attached to each jaw are two or three traveling chains whose purpose it is to bring the stalks to a vertical position and carry them back to the binding deck. The chains are placed one above the other (Fig. 10). The lower one is known as the short-corn chain, the middle one is the conveyor chain, and the upper one is the tall-corn chain. The middle chain passes around a sprocket wheel close to the point of the jaws, and extends back almost to the binding deck. The upper chain begins farther back and extends some distance over the binding deck. This chain is meant to carry the tops of tall corn. The lower chain is of about the same length as the upper one, begins nearer the point of the jaw, and does not extend so far back. The chains are supplied with fingers, which take hold of the stalks and lift them to a vertical position as the machine advances. The jaws have such a position relative to each other as will bring the fingers of the opposite chains almost in touch with each other at or near the cutting blades. The chains receive their motion from the main driving mechanism, and are driven at such speed as will bring the stalks to the proper position for cutting without shaking them too severely.

Cutters.—The cutting arrangement consists of a serrated knife which passes to and fro across two stationary blades, one of these being attached to each jaw. This serrated knife is driven by a pitman attached to a weighted wheel called a "flywheel." The added weight gives enough stored energy to sever the toughest stalks without shock to the small gear wheels (Fig. 11).

Attached to the rear of the dividers and extending around the binding deck are several guide springs (Fig. 9) which keep the tall corn from bending over and becoming entangled in the binding gear.

Binding Apparatus.—Just behind the knife and thence extending back to the bundle carrier, is the butt shoe, or butt carrier (Fig. 11). This device carries the weight of the stalks after they are cut. It is fastened to the frame just behind the knife, but through the rest of its length it is adjustable vertically, so that the binding twine may be placed at the proper place on both tall and short corn.

As the stalks are cut they are carried back by the conveyor chain, with their butts resting in the butt carrier until they reach the binding deck, where they are pushed backward by the packers, which have such a motion as will carry them perpendicularly through the binding deck and parallel to it while conveying the stalks to the knotter. Their motion is more rapid than that of the chains, but they have the advantage of yielding slightly while a bundle is being tied. This is important, as many ears would otherwise be knocked from the stalks by jamming the stalks behind the needle.

The needle and the knotter form the binding attachments. They are in nearly all cases of the same pattern as are those of the grain binders of the same makes, but are made heavier to meet the requirements of the work.

The packers on these machines must have such a motion as to travel toward the back of the machine as long as they project above the binding deck, their travel through the deck being fast and of short duration.

Draft.—The following results were obtained in draft tests of corn binders made by the author at the Iowa State College:

Draft Tests of Corn Binders.

| Binder. | Condition of Soil. | Empty, Out of Gear. | Empty, in Gear. | Cutting, Not Binding. | Cutting and Binding. | Cutting and Binding With Rows as Cultivated. |
|---|---|---|---|---|---|---|
| | | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. |
| 1 | Medium soft | 351 | 358 | 465 | 480 | 496 |
| 2 | Dry | 372 | 415 | 575 | 600 | 592 |
| 3 | Dry | 290 | 332 | 492 | 490 | .... |
| 4 | Dry | 235 | 252 | 442 | 560 | 473 |
| 5 | Dry | 267 | 298 | 451 | 468 | 448 |
| | Average draft | 280 | 345 | 489 | 500 | 502 |

The average draft on corn binders is about the same as that of a six-foot grain binder. The corn binder should, therefore, be propelled by three horses, the same as are required for grain binders. Draft tests of the corn binder, with a stubble-cutter attachment, show the following results:

| Draft of Corn Binder With and Without Stubble Cutter. | Pounds. |
|---|---|
| Draft with stubble cutter | 437 |
| Draft without stubble cutter | 420 |
| Draft of stubble cutter | 17 |

Cost and Efficiency.—In order to obtain full information regarding the efficiency of corn binders, questions were sent out to numerous farmers using corn binders in different sections of the country.

The average results, taken from the several hundred replies to the letter of inquiry, indicate that for all conditions of corn, the average number of acres of corn cut per day with a corn binder using three horses, is 7.73 acres. The average number of acres which one man can shock per day after a corn binder is 3.31 acres. The average number of pounds of twine used per acre of corn cut is 2.44. The average life in years of corn binders is 8.17, and in acres of corn cut, 668.77. The average first cost of corn binders is $125. The average cost of machine per acre cut, which includes price of machine, repairs, and interest on the investment, is 29 cents per acre; the cost of driver and team per acre cut is 46 cents, or $3.55 per day; the cost of twine is 30.5 cents per acre. The cost of shocking the corn after a corn binder is 44.8 cents per acre. This gives the total cost per acre of harvesting corn with a corn binder, $1.50.

The cost of cutting corn with the corn harvester and binder is, therefore, the same as the cost for cutting corn by hand, and 32 cents per acre higher than the cost of cutting with a sled harvester. This extra cost of cutting with the corn binder over the cost of cutting with a sled harvester may be attributed to the cost of the twine and the interest on the investment in the higher first cost of the corn binder. The corn binder has, however, proved a useful implement, the advantage over the other methods mentioned being the amount of work which can be accomplished per day and the general ease with which the work can be done.

One disadvantage which may be credited to the corn binder is that it knocks off more or less ears of corn, which either have to be picked up by hand, at a cost of about ten cents per acre, or left to waste or to be found by the cattle after the field is cleared.

Farmers who have not sufficient corn to cut to make it profitable to purchase machines sometimes hire the work done at a rate of 75 cents to $1 per acre for the use of the machine, the driver, and the team. The average cost of cutting given above was 29 cents per acre for the use of the machine, and 46 cents per acre for the driver and team, or 75 cents per acre. The charge for hiring the work done is only slightly above this.

(To be continued.)

## COST OF HAULING CROPS BY WAGON FROM FARMS TO SHIPPING POINTS.

AT an early date the United States Department of Agriculture will issue Bulletin 49 of the Bureau of Statistics, prepared by Frank Andrews, Transportation Expert of the Division of Foreign Markets. This bulletin is a report on the cost of hauling crops from farms to shipping points. The figures given are based upon returns from nearly 1,900 counties and cover practically the entire farming area of the country.

The average cost to the farmer of hauling wheat from farms to shipping points is given as 9 cents per 100 pounds, the average distance hauled is 9.4 miles, and the average wagon load of wheat weighs 3,323 pounds, thus containing about 55 bushels. For cotton, the average load is 1,702 pounds, distance from shipping point 11.8 miles, and cost of hauling 16 cents per 100 pounds. Reduced to terms of cost per ton per mile, the rate for wheat is 19 cents and for cotton 27 cents.

The highest cost of haul is for wool, which is carried on an average 39.8 miles from farm or ranch to shipping point at a rate of 44 cents per 100 pounds for the entire distance. The lowest cost for any one product is for hemp, which is hauled from farms to shipping points at an average cost of 6 cents per 100 pounds, the average distance hauled being 5.2 miles, and the average load of hemp weighing 3,393 pounds.

For the entire distance from farm to shipping point corn, oats, and barley are each hauled at an average cost of 7 cents per 100 pounds; hay, flaxseed, rye, and timothy seed, 8 cents; wheat, potatoes, and beans, 9 cents; tobacco and live hogs, 10 cents; rice, hops, and buckwheat, 11 cents; apples and peanuts, 12 cents; vegetables (other than potatoes) and cotton seed, 15 cents; cotton and fruit (other than apples), 16 cents; and wool, 44 cents.

Except in the case of wool, practically all costs represent the expense incurred by farmers in hauling their own produce. Wool is hauled in the Rocky Mountains largely by regular freight wagons, and the wool growers pay for the hauling at varying rates per 100 pounds.

The total tonnage of farm products hauled on country roads in the United States is not known, but of twelve leading products it is estimated that nearly 50,000,000 tons were hauled from farms during the crop year 1905-6, at a cost of about $85,000,000, or more than 5 per cent of their value at local markets. Of this traffic, 40,000,000 tons represent the weight of corn, wheat, and cotton, and the cost of hauling these three products was $70,000,000.

The number of working days taken to haul twelve leading crops from farms to shipping points during the crop year 1905-6 is estimated as 21,417,500, and the number of loads taken as 30,319,000. The greatest time for any one crop, in hauling to shipping points, is 8,494,200 days for corn; but if the time taken for hauling to local mills the wheat consumed in the counties where grown be included, the total number of working days taken for hauling wheat from farms

during the crop year just mentioned would be over 8,900,000.

Although there were fewer loads of cotton than of oats, it required 1,000,000 more working days for men and teams to haul the fiber than this grain, the average time for a round trip for hauling oats being 0.6 day and for cotton 1 day.

Including wheat hauled to local mills for grinding, the total number of wagon loads of the twelve crops just referred to was 34,200,000, and the services of men and teams for 24,500,000 working days were used in moving these loads.

The greatest distance over which it will pay to haul a given crop will practically limit the production of that crop for the market. Beyond that limit, a more valuable product must be made. Cotton is hauled a greater distance than wheat, and wool is hauled on an average more than four times as far as wheat and more than three times as far as cotton. Live animals are often profitable substitutes for crops on land remote from shipping points, for the animals may be driven at an expense far less than the cost of wagon transportation.

The distance limit of profitable farming for a given crop may often be extended by improving methods and means of hauling. Better wagons and horses may be used, roads may be improved, and better facilities may be had for receiving the products at local markets and shipping points. Improvements of this kind tend to lessen the expense of hauling a load, and thus make it profitable for farmers to haul from greater distances. From tables in the bulletin in question it is seen that average loads for the same product weigh in some States twice as much as in others, and consequently the expense of hauling is much less in the former States than in the latter for similar distances.

The average distances from farm to shipping point for twenty-one of the twenty-three products treated in this report range from 7 to 12 miles. The average distance over which hemp is hauled is 5.2 miles; oats are hauled an average of 7.3 miles; corn, 7.4; rice, 7.5; live hogs, 7.9; timothy seed, 8; peanuts, 8.1; potatoes and buckwheat, 8.2; hay, 8.3; rye, 8.4; barley, 8.8; beans, 9; wheat, 9.4; apples, 9.6; tobacco and vegetables (other than potatoes), 9.8; flaxseed, 10.4; cotton seed, 10.7; fruit (other than apples), 11.6; hops, 11.7; cotton, 11.8; and wool, 39.8 miles.

The most remote farms from which a certain product is hauled in small quantities may be easily several days' haul from a shipping point; but the product hauled, unless itself valuable, must usually be taken on the same load with goods of relatively high price. A few bags of corn or potatoes may be hauled 60 or 70 miles over mountainous roads to a local market and sold without loss to the producer if the same wagon carries also a considerable quantity of poultry and dairy products. From one community in the Rocky Mountains, wheat and oats are hauled on wagons a distance of 100 miles, cotton is hauled from one county in the Southwest 110 miles to a shipping point, while one report from west of the Rocky Mountains gives 165 miles as the length of the longest wagon route over which wool is taken from shearing camps down to a railroad station.

## CONCRETE SURFACES.*

By HENRY H. QUIMBY, M.Am.S.C.E.

THE ordinary concrete structure—whether of building blocks or monolithic masonry, and whether as left by the forms or as commonly finished for exposure to view—is anything but pleasing in appearance, and this fact seems to be the principal reason for the disfavor with which some architects and engineers regard concrete as a material for construction.

The blocks usually have a bubbly, artificial-appearing surface subject to a discoloration that is generally of a sickly or lifeless hue, which offends the eye quite apart from the unpleasant effect of the machine-like regularity of such blocks as are made in imitation of rock-face ashlar. Monolithic concrete is usually finished either by painting with a thin cement wash or by floating, and it is doubtful whether really satisfactory effects have ever been produced by either of these methods on work that was in the forms long enough to get quite hard. The material that ordinarily segregates against the mold forms a skin that seems to have the quality of making very uncertain the attachment to it of any coating, whether of neat cement, paint, or of plaster, and if no coating be applied to it and the skin be not removed, the appearance of the work, particularly after a little aging, can be adequately characterized only in language that is too picturesque for a serious paper.

There is, therefore, an active demand for a means of putting a better front upon a concrete body without overloading it in cost.

It has been suggested that a stucco finish can probably be made to adhere permanently, and it is reported that a plaster coating mixture of lime, cement, and sand has been tried with gratifying results. A very handsome appearance can undoubtedly be thus obtained, but it is generally as unlikely that the coating will endure wholly intact, and as certain that it will not unless the surface be first carefully prepared for it by some such method as treating with acid or by picking it rough, which altogether would make an expensive finish, and if portions should loosen and come off the condition would be shabbier than anything else that can be conceived.

* Paper read before the convention of the National Association of Cement Users.

The mere roughening, however, of the concrete surface to insure the adhesion of a coating of any sort, will itself, if completely and uniformly done, produce a pleasing and ordinarily satisfactory finish—provided, of course, that the concrete has a complete face fully flushed against the forms.

It follows, then, that tooling the surface to the extent of removing the film is a practicable and always available method of finishing it, and the tooling can be done with a bush hammer or an ax, by hand or pneumatic power. The tool should be light, and the blows only heavy enough to "scalp" the work, heavy tools and blows being liable to "stun" the concrete, particularly at and near edges. This scalping partially exposes the material of the aggregate but does not clean it. The complete exposure and cleaning will come with time and exposure to the weather if the work be outdoors; or the action of the elements can be anticipated by washing the tooled surface with a half-and-half dilution of hydrochloric acid, which, of course, must be thoroughly rinsed off.

The cost of such tooling, without subsequent cleaning with acid, has been variously found to be from three to twelve cents per square foot according to the character and extent of the work and the equipment.

Experiments upon small blocks have shown that a very expeditious method of removing the skin is grinding with a coarse-grained emery or carborundum wheel. The skin is cut about as quickly as the block can be well passed over the wheel, and although no actual comparison has been made and there is no knowledge of a trial of it on large work with a portable wheel, it would seem that with compressed air or electric motor and a flexible shaft the emery wheel might be used on any work with about the same facility as a power bush hammer, and the rapidity with which the wheel cuts away the face indicates that such a method of tooling will prove to be no more expensive than bush hammering. The wheel might be small in size and therefore of light weight for convenience in handling, and could be fitted with small guide rollers to limit the depth of cutting and secure reasonable evenness in the dressed surface.

Building blocks have been treated, without the preliminary tooling, by immersion for a sufficient length of time in an acid bath strong enough to dissolve the skin and some of the cement mortar between the particles of the aggregate, exposing and cleaning the particles and even leaving them in relief. This process, which is said to have been patented, includes washing after the acid bath, then immersion in an alakli bath to neutralize any absorbed acid remaining, then final washing with water. It is presumably expensive, is of necessity limited in its application to portable work, and care must be taken to avoid using in the concrete any sand or stone that is liable to injury by the acid.

It thus appears that the removal of the film and exposure to view of the clean aggregate by whatever method obtained is the essential feature of the most certainly durable and generally satisfactory surface finish of concrete. Of course, it should be understood that the surface must be fully finished—must be without cavities or visible voids between the stones. This condition can only be secured, when pressure cannot be applied, by using wet concrete thoroughly spaded or forked against practically water-tight forms, or by using with stiffer concrete a separate mortar or fine concrete applied against the face form with a trowel just in advance of the body concrete. Stiff concrete will not completely flush against the forms by mere ramming even if the ramming does work it to a liquid on the top of the layer. Care must be exercised with every portion of the face or voids will occur and appear when the forms are removed, and will necessitate patching. Such repairs cannot be made sightly unless at the time they are made the body is still green—before hard set has taken place. If the surface is accessible while still friable, blemishes can easily be removed without leaving a scar.

This fact suggests the desirability of early removal of the forms, and their removal after the concrete has set sufficiently to maintain itself, but before hard set has taken place, furnishes the opportunity for applying a treatment that is very convenient and inexpensive, yet produces the most pleasing and in all respects most satisfactory finish which has yet become known.

This process consists wholly in scrubbing the fresh surface with a brush and water, thereby removing the film, and with it all impressions of the forms, and exposing the clean stone and sand of the concrete. If it be done at the right time—that is, when the material is at the proper degree of set—merely a few rubs of an ordinary house scrubbing brush with a free flow of water to cut and to rinse clean, constitute all the work and apparatus required. A little additional rubbing will bring the larger particles into appreciable relief, which heightens the effect and, in the judgment of most observers, enhances the beauty of the face.

The practicability of removing the forms at the proper time for such treatment depends upon the character of the structure and the conditions under which the work must be done. The system cannot be applied to the soffit of an arch nor to the underside of a reinforced concrete floor, because the centering must be left as support so long that the surface against it is almost stone hard. If, however, the surface material there is the same as at the sides which have been scrubbed, the soffit can be brought to match the sides by tooling and then cleaning with acid and water as before described.

The texture and color of the surface obtained by this process will vary with the character of the aggregate of the concrete, because in a mixture of cement and sand and stone the cement is in small proportionate volume and has but little influence on the color of the ensemble. Some opportunity is thus afforded for the exercise of individual taste in texture and color, and it is very easy to arrange a quiet color scheme in any work that may be suited to it. Warm tones can be obtained by the use of crushed brick or red gravel. A dark colored stone with light sand will produce a surface that resembles gray granite. Fine gravel gives an appearance so like sandstone that even close examination will not enable one to distinguish between them. In the construction of monolithic concrete masonry for bridges for the city of Philadelphia it is the practice to use a fine concrete or granolithic face composed of (1) cement, (2) bank sand, and (3) crushed and cleaned black slaty shale, of the size commonly used for tar roofing—say ¼-inch to ⅜-inch. This mixture is placed against the face forms and the body concrete is placed against it and rammed into it immediately. In the three years since this process was adopted and during which it has been applied to twelve bridges, no case of separation of granolithic face has been observed, and not a single hair crack has been found, nor any kind of deterioration or tendency to discoloration noticed—indeed the weathering seems to make the surface cleaner and more stone like.

In general, the washing is done on the day following that on which the concrete was deposited. Portland cement is used. When a quicker setting cement than usual is met, or through some other influence the surface is found, upon removing the forms, to be too hard for the scrubbing brush, a wire brush is employed first, then a small block of wood or a brick bat with water and sand, which is found necessary to cut the film.

If the surface has hardened so as to require the grinding action of the sand and block the aggregate will not be brought out into very decided relief and the face will therefore be comparatively smooth. In cold weather when crystallization proceeds slowly the forms may require to remain two days before the washing can be done safely, and in very cold weather they have been left a whole week and the scrubbing was successful.

Consideration of the cost of the process may involve the question of the design of the forms. When the work is such that not the whole height of it can be placed in one day it may be advisable to construct the form so that the planks can be removed without disturbing the uprights. This will add to the cost but may be compensated for by saving in planks. In the case of a long or heavy wall where only one course can be laid in a day only one course of planks is required.

If indentations are made at the joints between courses, the joints can easily be concealed. If the indentations are not desired great care must be taken to scrape thoroughly clean the top of each course quite to the face and to use the same consistency of the new granolithic facing as that of the lower course. It is possible thus to make a joint that will not be very noticeable, but the vigilance of the inspector must not be relaxed at any point, and even then the joint will be at least distinguishable. The bead indentations are very convenient and useful in working, and in appearance they relieve what otherwise would be a large blank area.

When the planks are desired to be removable the studs are set some distance from the face—8 inches to 12 inches—and the planks are braced against them by cleats nailed so as to be easily loosened. The planks are in one width the full depth of a course, either solid or made up of narrow planks battened together. A triangular bead strip is nailed to the face at each edge and the layer of concrete is finished at the middle of the top bead.

When a plank is taken off it is scraped clean of adhering cement, then oiled, and reset with its bottom bead fitted into the half indentation just left by the top bead.

A couple of carpenters with perhaps a helper will take off and reset a course of plank say 100 feet long in four to eight hours. The course may be whatever is desired for either convenience or architectural effect. The yardage of concrete accommodated will vary also with the thickness of the wall and of the proportions of face to back Thus the cost of changing forms will vary from 25 cents to 75 cents per cubic yard. In building work generally the ordinary forms can be used. Of course, care must be taken not to load members too heavily while they are green and naked, but the same care should be exercised with members still in forms because the forms while preventing collapse will not prevent injury to the concrete by undue pressure upon it.

The cost of the scrubbing is trifling if done at the right time. A laborer may wash say 100 square feet in an hour, or the same area if it has been permitted to get hard may take two men a whole day to rub into shape.

The early removal of the forms makes possible the neat repair of any blemishes that may be revealed.

The question of efflorescence is an important one in the consideration of the appearance of concrete structures. The scrubbed surface is not subject to the hair cracks that in some faces seem to absorb moisture during storms and then exude the white spreading disfigurement. But if there are joints in the work there is danger of the efflorescence, and observation leads

to the belief that if within twenty-four hours of the completion of a course the top surface be carefully scraped to remove every particle of the "laitance," and then before depositing the next layer of concrete the scraped surface be coated with thin cement mortar, the joint ought to be impervious to moisture from either front or back, and no trouble with efflorescence ensue.

The following aggregates give a satisfactory surface when made into concrete and treated as above described:

1. Granite screenings.
2. Crushed red clay brick.
3. Crushed red shale paving brick.
4. Screened yellow bank sand.
5. Screenings of yellow bank sand.
6. Quartz sand.
7. Unscreened yellow bank sand.
8. Bar sand.
9. Black slaty shale stone with bank sand.

## ADVANTAGES AND APPLICATIONS OF THE ELECTRIC DRIVE.*

By F. B. CROCKER and M. ARENDT.

THE great economies effected in many manufacturing establishments by the substitution of electric drive for the older methods of countershafting and belting have resulted in the rapid extension of this branch of electrical engineering. Many factory managers anxious to decrease running expenses, or increase the plant output, are led, by a general knowledge of what has been accomplished, to believe that this substitution would produce both results. In many instances the desired results may be obtained, and in others, affairs would not be improved, either owing to the fact that the conditions of operation are not suited to the electric drive or because the wrong types of motors or motor control were employed.

It is impossible to give any exact rule which would determine when to adopt the electric drive, or when not to. Each case should be considered according to its own particular features, and the reasons for and against the change must be carefully studied, in order to be able to decide correctly which system or modification would produce the best results in all respects. It is necessary not only to consider the increased output or reduced power bills, but also take into consideration the items of first cost, interest, depreciation, maintenance, and other facts discussed in detail later.

Electric drive may be divided into three general classes, as follows: One motor for the entire plant; group drive, when the machines in each section or bay are driven from one motor common to that section only; individual drive, when each individual tool is equipped with its own motor.

The common motor drive is equivalent to the ordinary engine or other prime mover drive, and employs like them a system of countershafts and belts, its advantage being the convenience of electric transmission of power, in comparison with a steam engine plant and its attendants, as well as reduced first cost of the equipment. It is also employed when the plant is too small to be economically divided into groups or operated by individual motors. The running efficiency under variable loads thus secured is higher than that of the steam or gas engine, and while this is an advantage, the saving made is too small to consider by itself.

The group drive is a compromise between one common motor and individual machine drive, and its employment is frequently advisable. For example, consider a factory having no rush season, but a steady demand for its finished product, so that the work can be turned out according to a certain definite schedule, with the labor so divided that every two or more men operate a certain group of tools, which are used therefore in rotation, and not at the same instant. In a case like this, only one motor is necessary for each group, but it must be large enough to drive the heaviest machine connected to it. The connections are made by countershafts, friction clutches, and belts, so arranged that only the particular machine in use is being driven.

It is advisable in such an equipment to have tools requiring approximately the same power in the same groups, because by so doing, the average size of the motors will be kept down and the first cost reduced.

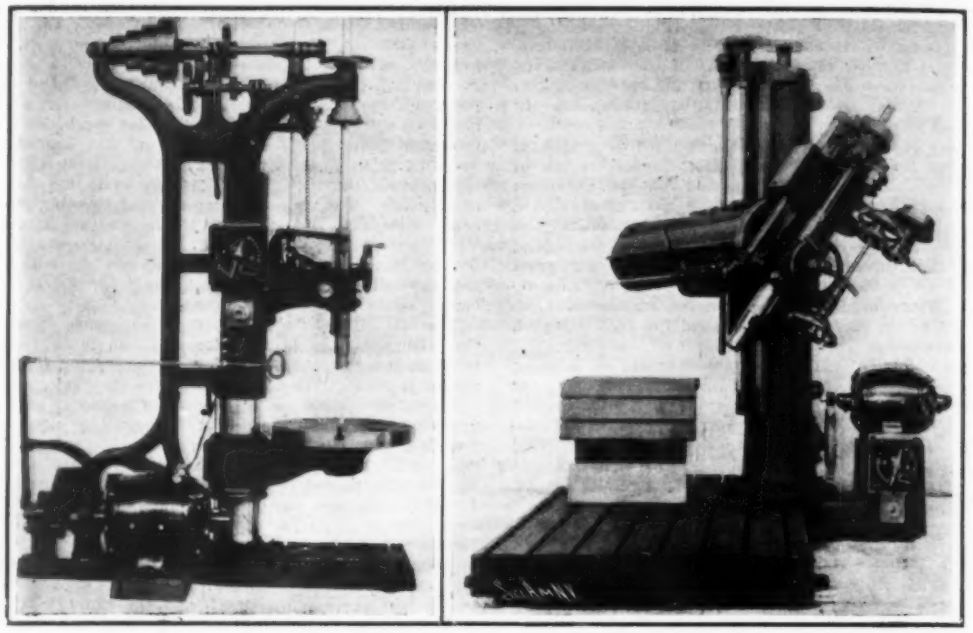


FIG. 3.—RADIAL DRILL AND UNIVERSAL RADIAL DRILL DRIVEN BY 2 AND 3-HORSE-POWER MOTORS RESPECTIVELY.

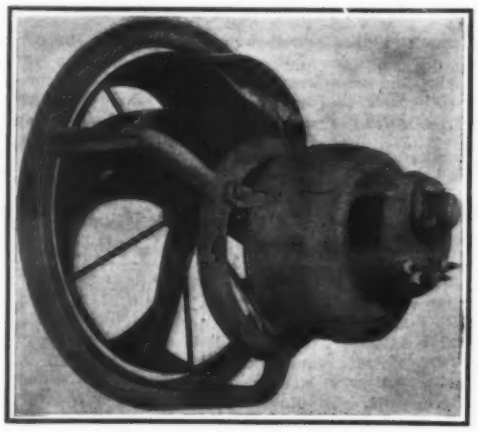


FIG. 1.—A DIRECT-CONNECTED BLOWER.

Group drive is to be recommended, when several similar machines are to be run, each machine requiring only a small amount of power, as for instance in the case of a collection of sewing machines, small saws, grinders, polishers, buffers, etc.

Individual Drive.—When the establishment is large and wide ranges of speed are desired, with machines differing greatly in capacity and performing totally different functions, individual drive is to be recommended, on account of the independence of the various machines, reduction in shafting and belting losses, etc. The motor may be connected to the driven apparatus by one of three general means, i. e., direct-connecting, gearing, or belting. The first method is employed when the normal speed of the machine is high and corresponds to that of the motor. Very low-speed apparatus should not be driven directly, because the cost of the motor would be excessive, low-speed motors being larger than high-speed ones of the same capacity. When the required reduction of motor speed is small, and does not exceed 3 to 1, belting answers well if the distance between driving and driven shafts can be made considerable and the power to be transmitted is not great. If the distance between shaft centers is necessarily small (less than four times the diameter of the driving pulley) and the power to be transmitted is considerable, say over 10 horse-power, a modified form of belting, i. e., noiseless chain drive, is to be recommended. When reduction of driving speed is large and the motor can be placed close to the tool, gearing is to be recommended as the means for transmitting the power. The flexibility of the belt drive is sometimes an advantage since it does not produce the shock upon the motor due to sudden load variations; as for example, those occurring in punching and shearing.

The conditions under which machinery operates in regard to varying speed and power required of the driving motor may be divided into four classes, and a special type of motor is usually best suited to each of these divisions.

(*a*) Work which requires the motor to operate automatically at a constant speed, regardless of load changes or other conditions.

(*b*) Work requiring frequent starting and stopping of the machine, and wide variations in speed, including sometimes rapid acceleration.

(*c*) An approximately steady load, or where the work varies as some function of the speed, should it change.

(*d*) Work in which the power varies regardless of the speed, or where speed variations with constant torque may be desired.

The first class (*a*) applies to line shaft equipments, with many machines operated by the same motor; and where slight speed variations may be allowed, the alternating-current induction motor, the direct-current shunt, or slightly compounded motor would answer, depending naturally upon the character of electric current available. A special refinement of this problem is encountered in the driving of textile machines where a slight speed variation might influence the appearance of the finished product; in such instances the alternating-current motors, polyphase induction or polyphase synchronous are necessary, because the speed of the direct-current motors will vary considerably with voltage changes and variation in temperature which occurs after several hours of operation. Whereas the speed of the alternating-current motors, unless the voltage varies greatly, is primarily dependent upon the frequency of the supplied current.

* Portion of Lecture Notes on Electric Power. Electrical Engineering Department Columbia University. Published in the School.

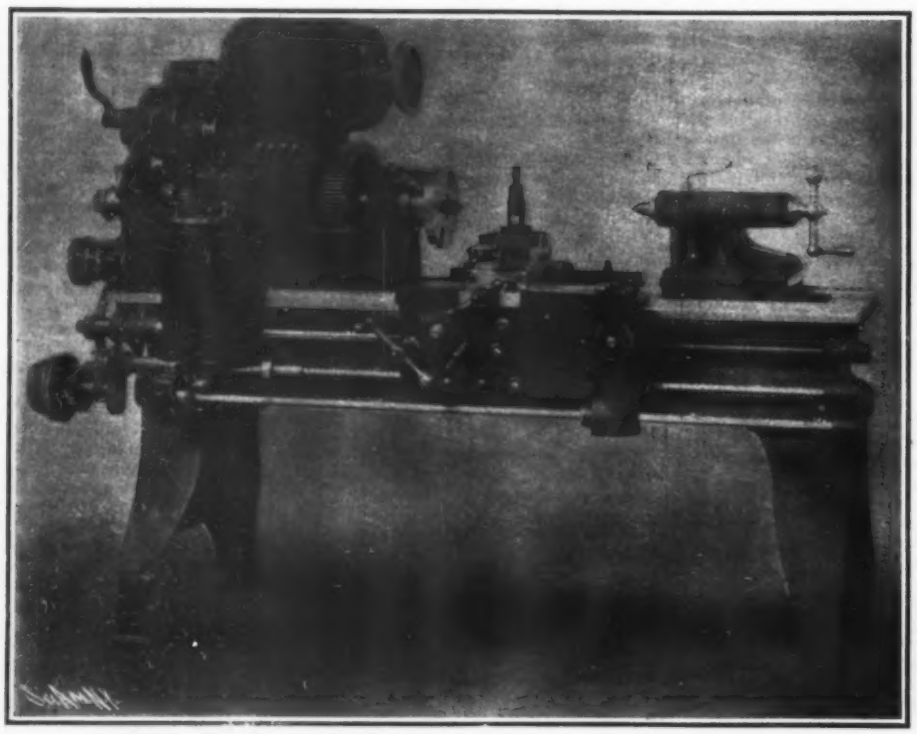


FIG. 2.—16-INCH ENGINE LATHE.

The second class (*b*) is divided into two parts, the first being applicable to electric traction and crane service, for which the motor is frequently started and stopped, and rapidly accelerated at starting; or where the speed is to be adjusted automatically to the load, slowing down when heavily loaded or climbing a steep grade. These conditions are well satisfied by the series motor, of either the direct or alternating current type, depending upon the current supplied. Elevator service is of this class, as regards frequent starting and stopping, but after being rapidly accelerated it calls for a speed independent of the load; therefore, to obtain both requirements, elevator motors when of the direct-current type are heavily over-compounded, to give the series characteristic at starting; then, when the motor is up to speed, the series field winding is short-circuited and it operates as a shunt machine. If only alternating current is available the polyphase induction motor should be employed, but for powerful starting torque either slip-ring or compensator control would be necessary. In the second subdivision of this class the motor must be started and stopped frequently, and not rapidly accelerated, but on the contrary simply "inched" forward at start, as met with in the operation of printing presses and similar equipments. These conditions of service are satisfied by a direct-current compound motor, provided with double armature and series-parallel control of the machine as manufactured by the C. & C. Electric Company. They are also well satisfied by the scheme of having a double or variable potential source of current supply for the working motor, low voltage at starting and "inching" positions and higher values at running points. These features are supplied by the Bullock-Teazer system, or by the Ward-Leonard motor-dynamo equipment, the latter, however, being so expensive that its use is almost entirely restricted to the operation of gun turrets, etc.

The third class (*c*) applies to the operation of pumps, simple fans, or blower equipments, and its requirements are best satisfied by the series motor, since the maximum torque is required at starting. It must be, however, either geared or direct-connected to the apparatus, because the breaking of the belt or the sudden removal of the load would cause the motor to race and become injured. The operation of pumps by electric motors is usually accomplished by gearing, since ordinary plunger pumps do not operate efficiently if driven in excess of fifty strokes per minute, and to accomplish this by direct connection would demand a very low speed and costly motor. Centrifugal pumps operating at higher speeds may be direct connected.

The fourth class (*d*) is found in ordinary machine-shop practice, where operation at maximum cutting or turning speed allowable requires the number of revolutions of the work or tool to vary inversely as the diameter of the piece of material being worked upon; this condition is satisfied best by the direct-current shunt or slightly compounded motors, as they are readily controlled in speed by variation of applied voltage, shunt field weakening, etc. In a well-known 24-inch screw-cutting lathe, the driving element is a shunt-wound motor, supplied with current from a multiple voltage system and equipped with a 21-point controller; it drives through a silent chain to a sprocket which may be connected directly to the spindle or through either of two back-gear combinations. The first combination gives a variation in speed of 1:2.68 and through the second a further change of 1:2.63 is obtainable. The highest speed of the motor is 1,270 revolutions per minute and the corresponding speeds of the spindle 285, 108, and 40.4 revolutions per minute. The upper twelve speeds of the motor when driving the spindle directly, the same on the first gear combination, and the upper eighteen on the second, constitute the tool's working speeds, forty-two in all. The motor will give an output of 3 horse-power at any speed within this range. Obviously the motor may be run on slower speeds at reduced power, and with the slowest gear combination, as low as four revolutions per minute of the spindle is possible. These extremely low speeds are convenient when setting up work, or when a very low cutting speed is desirable. The controller is manipulated from a hand wheel supported on the carriage, the connection being through gears and a spindle shaft, so that the motor is under instant control of the operator at whatever position along the bed the carriage may happen to stand. The same conditions of service, as above outlined, are met in the case of drilling, milling, surfacing, and turning machinery.

In the general operation of variable-speed tools, direct-current motors are used, as alternating-current induction motors are not adapted to efficient or convenient methods of speed variation, usually depending in such cases upon variable gearing or cone pulleys.

(To be continued.)

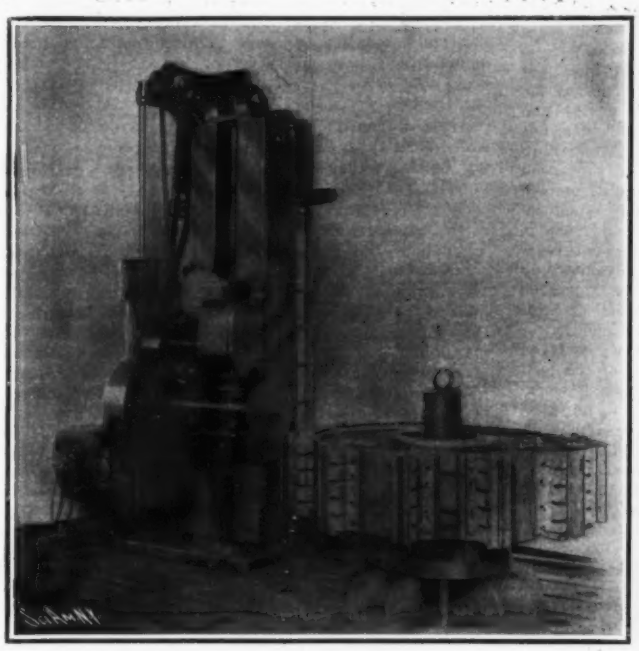


FIG. 6.—VERTICAL GRINDING MACHINE.

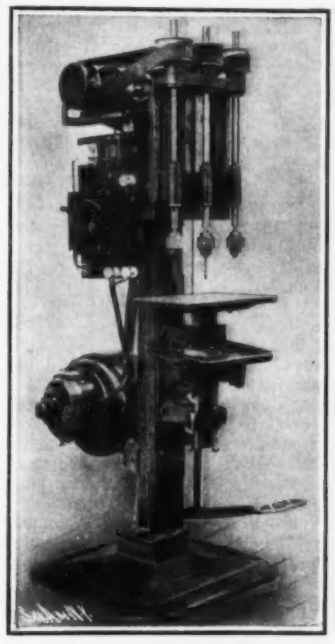


FIG. 8.—THREE-SPINDLE DRILL PRESS.

## DYNAMO BRAKE FOR THE ACCURATE RATING OF GASOLINE MOTORS.

By the English Correspondent of SCIENTIFIC AMERICAN.

IN view of the unsatisfactory methods at present adopted for the rating of gasoline motors, and the great divergence in the stated horse-power of similar engines by various manufacturers, notwithstanding the facts that stroke, bore, speed, and compression area are exactly the same, some means of determining the power capacity with unimpeachable accuracy has long been required. The existing system has numerous shortcomings, the dependence upon the human element, which enters very largely into the calculations, being mainly responsible for the dissimilarity in the results. It is for this reason that great interest is being evinced in a new appliance that is being introduced among the engine manufacturers of Great Britain.

This brake dynamo not only considerably facilitates the process of testing the engine, but it eliminates all possibility of inaccuracies. In its most complete form it is absolutely automatic in action, and presents a continuous record of the actual power developed by the engine at minute intervals during the whole period it is under test. Moreover, the motor can be run at different speeds, and the records obtained are equally conclusive.

The apparatus comprises a dynamo, to the armature of which the motor to be tested is coupled direct either by pulley or chain, according to which method is the most convenient. The magnet frame is, however, so arranged that it is free to oscillate. For this purpose it is carried on a cast-iron bedplate by two ball races fitted into the bearings, the travel of oscillation being limited by suitable elastic stops. Instead of the friction generated by the usual rope brake or other contrivance, the electromagnetic reactions are used, since they tend to rotate the magnet frame in the direction of the revolving armature. As the turning moment is exactly equal to the electromagnetic reaction, it can be readily measured with absolute accuracy. The brake power thus exerted is measured by a graduated steelyard counterbalancing the tendency of the frame to rotate. The measurement of the moment is obtained by means of sliding and loose weights acting on the steelyard at a radius from the center of the shaft. At zero the machine is balanced by a counterweight. All bearing friction and other sources of possible error are balanced by the machine, so that no allowances of any kind need be made. By means of the balancing force applied to the magnet frame, the torque can be readily measured and the power exerted, which is absolutely that of the engine, calculated by the usual Prony formula.

The foregoing is the simplest type of instrument. If required, the moment can be measured without the

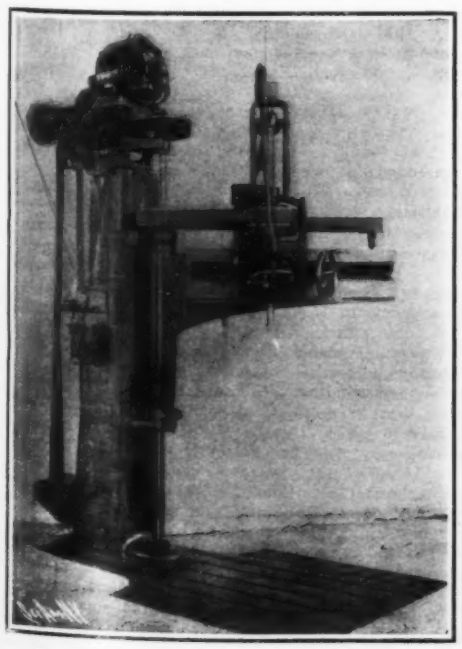


FIG. 4.—BELTED RADIAL DRILL

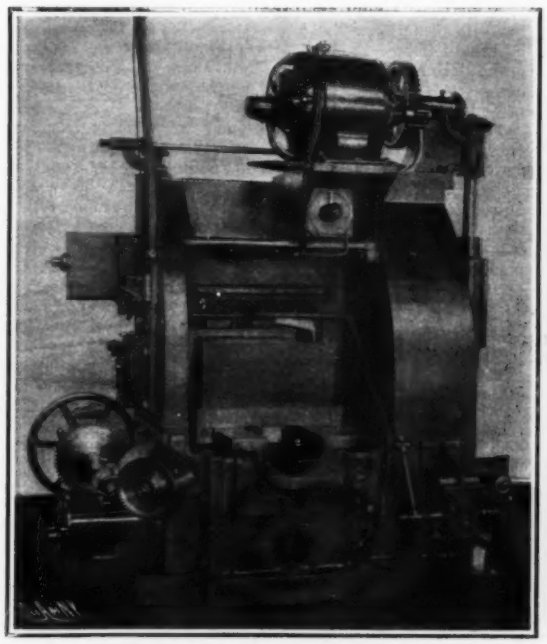


FIG. 5.—CIRCULAR MILLING MACHINE WITH 4 TO 7-HORSE-POWER MOTOR.

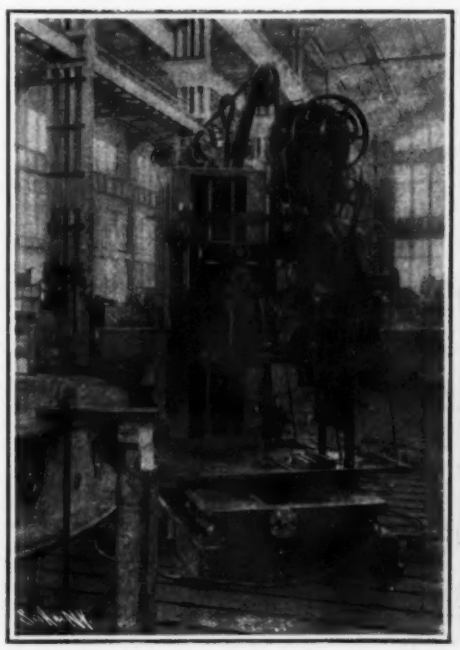


FIG. 7.—PORTABLE SHAPER.

ADVANTAGES AND APPLICATIONS OF THE ELECTRIC DRIVE.

necessity of adjusting weights. In this instance the steelyard is displaced by a fulcrum, which bears by means of a ball on a piston working in a vertical cylinder connected with a pressure gage, which indicates the force exerted in pounds. For measuring the speed, a tachometer, preferably of the electric type, with self-registering dial, is used. By this means the readings can be readily watched and easily recorded.

The automatic type, while somewhat more elaborate in character, is preferable, since in this instance it is entirely automatic and self-recording, and does not require any attention whatever during the period the motor is under test. The essential parts of the machine are exactly the same as in the simpler type, but in addition there are gages connected with two indicating arms, recording in the one instance the speed of the engine, but in the other the forces developed. The two indicating arms trace their readings synchronously upon diagram cards, and the second gage is so graduated that the simple product of the two readings gives the actual brake horse-power developed by the engine. It will thus be seen that these two cards combined give a permanent, trustworthy test sheet of every engine tested. Throughout the whole course of the test a clear record of speed and power developed is made for every moment of the duration of the test, as the indicator cylinder carrying the diagram is worked by a clock, and the cards are graduated in minutes. Once set in motion, the plant requires no further attention during the period of test, but if desired, adjustments can be carried out and the results can be followed upon the diagram sheets. Moreover, there is no appreciable waste of electric energy, since the current can be connected in the accumulator charging, or coupled in parallel with the main circuit in the works. If preferred, however—and in some instances such a course is desired—this energy can be dissipated by means of liquid or metallic resistances, but the latter is the more reliable, more easily regulated, and requires no maintenance.

This brake dynamo has already been established in the works of many of the leading French gasoline motor manufacturers, various capacities being employed for the different-powered engines. The largest yet installed is that at the marine motor works of the Automobiles-Brasier at Ivery-Port, which operates up to 270 horse-power, though they have five others ranging from 35 to 140 horse-power. Owing to the infallibility and incontestability of the results obtained, which are absolute, it is also utilized in the rating of gas and heavy oil engines, while a large plant of 2,000 horse-power capacity is being designed for installation at the works of a well-known English firm of steam turbine manufacturers.

## ELECTRICITY AND VEGETATION.*

WITHIN recent years a number of processes have been devised to render available as a plant food the seemingly worthless nitrogen content of the atmosphere. What has been achieved in this direction by long-continued and laborious effort, is nothing more than what has always taken place in nature; for while it was formerly believed that plants are incapable of acquiring nitrogen from the air, recent investigation has clearly shown that the nitrogen taken up by plants is not only derived from the soil, but in large part also has its source in the atmosphere. The utilization of atmospheric nitrogen for this purpose is due to the activity of certain micro-organisms that are capable of transforming gaseous nitrogen into an assimilable form. Another agency which helps to make nitrogen available as a plant-food is electricity. It is well known that air contains traces of nitrogen compounds, the formation of which is due to powerful electrical discharges such as take place during thunderstorms. But while the amounts of nitrogen compounds produced in this manner are negligible, the so-called silent discharges constantly going on between the different air strata are of very great importance in rendering nitrogen assimilable. It is to Berthelot, the Director of the Agricultural Station at Meudon, near Paris, that we owe our knowledge of the influence which such electrical phenomena exert upon the acquisition of nitrogen by the soil and, indirectly, by the plants. Experiments had been previously made to ascertain the effect of high-tension discharges, and plants had also been introduced into the circuit of an electric battery, by which means a stimulation of the vital functions was affected. But in these cases special conditions, very unlike those existing in nature, had to be created. In some preliminary experiments Berthelot studied the effect of the silent discharge of a battery of 5 Leclanché cells upon the absorption of nitrogen by organic compounds. The results were quite remarkable. Under the conditions prevailing during these experiments not even traces of ammonia, nitric acid and hydrocyanic acid were formed, and any ozone produced by the discharge was found incapable of oxidizing the gaseous nitrogen. The substances employed included ether, benzene, paper, and dextrin.

The apparatus used in these experiments consisted of two glass bell-jars of which the larger one is provided with a metal coating, forming one of the poles. The smaller jar is coated inside with metal foil which constitutes the positive pole. In the space between the two jars the substances to be experimented upon are placed, so that they are separated from the poles by a dielectric. When the substances are left in contact with air or nitrogen under these conditions and for periods of nine months, considerable quantities of the nitrogen disappear. This nitrogen enters into the composition of the organic substance, where it forms an amide from which ammonia can be liberated by heating with soda-lime. The following figures were obtained in experiments with paper and dextrin.

1,000 parts of the original substance contained:

| | Nitrogen. |
|---|---|
| Paper | .10 parts |
| Dextrin | .12 parts |

After 1 month's exposure to discharge from 1 Leclanché cell:

| | |
|---|---|
| Paper | .10 parts |
| Dextrin | .17 parts |

After 7 months' exposure to discharge of 5 Leclanché cells:

| | |
|---|---|
| Paper | .45 parts |
| Dextrin | 1.92 parts |

On increasing the distance between the jars the nitrogen yield was diminished:

| | |
|---|---|
| Paper | .30 parts |
| Dextrin | 1.10 parts |

Hence it is seen that a considerable absorption of nitrogen has taken place; the substances absorbing this nitrogen are non-nitrogenous constituents of plants and the differences in potential under which the absorption occurs are about those constantly existing in the atmosphere at some distance from the surface of the earth. The figures also show that an increased difference of potential produces an increase in the amount of the nitrogen absorbed. When electric contact is broken in these experiments, no nitrogen whatever is found to be taken up by the organic substance. To imitate more closely the natural conditions, Berthelot repeated his experiments, substituting atmospheric electricity for the battery. The apparatus employed was similar to that above described. One of the metal foils was connected with the ground, while the other was connected with a commutator placed in an open field. The substances experimented upon were thus exposed to the atmospheric electric tension.

In all cases where dextrin and paper were exposed to air or nitrogen, either in a closed space or in a current of these gases, considerable quantities of nitrogen were invariably absorbed. The produce invariably contained amido-bodies from which ammonia was liberated by heating with soda-lime at temperatures of 300 to 400 deg.

When paper or dextrin is exposed to air without being placed in an electric field, not the least indication of an absorption of nitrogen could be detected. As a matter of course, the amounts of absorbed nitrogen are very small; they rarely exceed 2 per cent of the weight of the substance employed. Similar conditions exist in nature. It is not only the violent discharge of electricity during thunderstorms which effects the chemical combination of atmospheric nitrogen, but the far more important effect of the silent discharges between different layers of air. In view of the fact that this latter reaction extends over an enormous space and proceeds without interruption, we must conclude that its aggregate effect is enormous. The particles of organic material floating in the air are thus nitrogenized, and then pass into the humus of the soil. How else could we explain the crops of leguminous plants containing a larger amount of nitrogen than could have been acquired from the soil, the fertilizers, and the nitric acid and ammonia contents of the air? The luxuriant vegetation seen on mountain meadows to which fertilizers are never applied, doubtless derives much of its nitrogenous food from the products of unusually active discharges of atmospheric electricity.

Berthelot has further determined the quantities of nitrogen acquired by the soil and the plants during the growth of the latter, both within and without an electrical field. Without exception, these investigations have revealed the fact that electricity exerts a very marked influence upon the absorption of nitrogen. Is this absorption a direct function of the plant, or should it be attributed to a stimulation of the vital activities of the microbes and the plants? A definite answer to this question can hardly be ventured in the present state of our knowledge.

The experiments just mentioned were made with two soils containing per kg. 1.213 and 1.702 g. of nitrogen respectively. The latter amount must be regarded as the maximum nitrogen content which can be acquired by the soil. The vessels employed were made of porcelain and had the shape of plates and pots. It was found that the absorption was most rapid in the pots, the lower layers of the soil showing the greatest accumulation of nitrogen. When plates were used so that the soil had to be spread out in thin layers, the results were not very satisfactory. Part of the experiments were made in a freely circulating atmosphere under glass cover, and in another part the vessels were placed under a bell-jar of 50 l. capacity. In the latter series fresh air and carbonic acid were from time to time admitted to the contents of the jars. The soil was also supplied with a sufficient amount of moisture. The electrical field was produced by means of a battery having a voltage of 32. One of the poles was connected with the soil, while the other consisted of a wire gauze suspended above the vessels. Where the bell-jars were employed, the second pole was formed by a metal grating upon the inner walls of the glass. In these cases, however, the interception of the light rays by the metal coating proved prejudicial to the growth of the plants.

In the pots were planted the seeds of vetches and jarosse, the organic substance and nitrogen content of which had been carefully determined. Analyses were also made of the soil, the parts of the plants under the soil, and the parts of the plants exposed to the air. We cannot enter here into a detailed description of these experiments, but the results are given on the subjoined tables.

These give the nitrogen values of the materials both with and without electrical influence. When the plants were not exposed to an electrical field, the assimilation of nitrogen must be attributed to the action of bacteria. A larger absorption of nitrogen was observed where the soil was subjected to electrical discharges, and this surplus must be credited to a stimulation of the bacterial activity.

TABLE I.

**Absorption of Nitrogen by Soil Under Influence of Electricity.**

| Experimental Conditions. | | | Nitrogen Absorbed. |
|---|---|---|---|
| Soil on plate.... | Free access of air, glass roof ..... | (a) Not electrified | none |
| | | (b) Electrified, 33 V | none |
| | Bell jar of 50 l .. | (a) Not electrified | none |
| | | (b) Electrified, 32 V | 4.4% |
| | | (c) Electrified, 132 V | 6.1% |
| Soil in pots, ... | Free access of air, transparent roof | (a) Not electrified | 2.2% |
| | | (b) Electrified, 32 V | 3.6% |
| | 50 l. bell jar..... | (a) Not elec., 30 V. | Lapse. 4 weeks none. 9 weeks 2.8%. |
| | | (b) Electrifi'd, 30 V. | 4 weeks none. 9 weeks 4.6%. |

TABLE II.

**Absorption of Nitrogen With Vegetation in 3 Kg. Soil.**

| | | | | —None Absorbed— Soil. | Plant. |
|---|---|---|---|---|---|
| Soil and vetch | Open air | Not elec... | 1 month | .179 kg—3.4% | .045—1% |
| | | Elec. 32 V. | 1 month | .329 kg—6.2% | .046—5% |
| | Bell jar.. | Not elec... | 1 month | .340 kg—6.4% | .027—1% |
| | | Electrified. | 1 month | .204 kg—3.9% | .070—4% |

The figures given in these tables attest the very pronounced influence of electrical discharges upon the development of vegetable organisms. It might be interesting to investigate in a similar way the effect of electricity upon the sprouting barley. It is probable that the growth of the latter would be accelerated and its yield of extract increased. In this way, then, atmospheric nitrogen could be utilized for food-stuffs (beer, for example), a result which has hitherto been accomplished only by means of fertilizers like calcium cyamide (see Pure Products, 1906, p. 446).

One experiment at least in this direction has been tried. It consisted in allowing an electric current of high voltage to pass through a layer of steeped barley. The somewhat discouraging results of this experiment may be accounted for by the disturbing effects of such strong currents upon the organism of the grain.

A German patent also refers to the electrical treatment of the sprouting barley. Two or more electric currents are allowed to pass in parallel direction through the grain and parallel to the bottom of the germinating vessel. The upper current must be stronger than the lower one. The apparatus is so arranged that only one current enters the grain, but is then divided into a number of currents flowing parallel to the bottom of the vessel, the resistances being regulated so as to gradually increase from the top toward the bottom.

Berthelot's investigations on the relations existing between electricity, nitrogen absorption, and vegetation, must be regarded as preliminary work for an electric malting process.

[Continued from SUPPLEMENT No. 1591, page 25490.]

## UTILIZATION OF WASTE MATERIALS.—II.*

### CORK WASTE.

THE waste scraps from cork cutting are either used as they are for stuffing mattresses, cushions, buffing baskets, etc., or they are sorted, stripped of any bark adhering to them, and used for the same purpose, or again—and this is the principal use to which they are applied—are converted into powder of various degrees of fineness. The chips are first freed by hand with sharp knives from the rough and dark outer bark of the slabs, cheap labor only being necessary for this process, are then cut into laminæ of varying thickness, and finally into cubes of different dimensions.

Cork waste is also treated by filing or rasping, more or less fine chips being produced by this means. It is evident that the degree of fineness of the chips has an important bearing on the price.

The woody portions of the waste and also the peculiar hard sandy powder found in the cork is removed partly by sorting and partly by sifting, in order that the waste may be as free as possible from these substances. Specially-constructed machines are employed for grinding the waste, one of the most useful being a machine made by H. R. Glaser, of Vienna, and known by the name of the patent Favorita mill.

The machine consists of a cast-iron lower frame supporting the case of the mill, together with the contrivances for grinding, filling, adjusting, and the transmitting disk. The mill operates by means of two conical surfaces geared together, and provided with concentrically arranged geared teeth of triangular cross section. One of the conical surfaces revolves while the other remains stationary, being fixed to the case. The grinding teeth slide over each other in such a way that the waste introduced at the top of the cone and driven to the circumference by the centrifugal force of the revolving cone is cut to pieces, and crushed as if with a pair of scissors. The grinding surfaces can be brought together and separated during the working of the mill by means of a handwheel; a difference in the degree of fineness of the waste can

* Pure Products.

* Specially translated for the SCIENTIFIC AMERICAN SUPPLEMENT from the German of Dr. Theodor Koller in "Verwerthung von Abfallstoffen aller Art."

be secured in this way. The teeth are affixed to segment-shaped plates which can be changed, and the mill grinds finer or coarser according as the teeth on these segments are smaller or greater and distributed with smaller or greater intervals between them. The degree of fineness of the product depends also on the velocity with which the cone revolves.

*Utilization of Cork Waste in the Manufacture of Gas.*—Illuminating gas is made from cork waste in the ordinary manner in closed retorts. One hundred pounds of the waste yield about 800 cubic feet of gas, and the process of distillation is much more rapid than that of coal. The illuminating power of the gas with a consumption of 5.3 cubic feet per hour—using a No. 10 butterfly burner—amounts to 36 candles, the result being a saving of 50 per cent, together with greater illuminating power, as compared with coal gas supplied elsewhere at the same price. The cork tar, produced as a by-product, has the consistence of ordinary tar and is red-brown in color; it yields with fractional distillation 27 per cent of light oil, passing over at 410 deg. F. and consisting essentially of benzol and toluol with some naphthaline. The heavy oil contains anthracene and a little phenol; the liquid condensed in the manufacture of gas contains methyl-alcohol, acetic acid, and ammonia.

*Cork Waste for Cork Mattresses.*—To make mattresses of this kind, coarse, highly waterproof material is sewn or stuck together so as to form a large sack into which the cork waste or cork dust is put; the sack is then sewn together and quilted until it gets the shape of a mattress. To secure complete impermeability to water, all the seams and places where the quilting has been done are coated with a solution of India rubber. When the latter dries, the mattresses are ready for use.

Mattresses for gymnasiums are made in the same way, except that ordinary coarse material is used. Buffing baskets for ships are sacks or baskets filled with cork waste.

*Utilization of Cork Scrap in the Manufacture of Vinegar.*—It has been recommended to replace wood chips in the manufacture of vinegar by the much lighter cork waste. The elasticity of the cork is increased by wetting, therefore there is no danger of the filling shrinking, even in tall vinegar generators. Innumerable small organisms are to be found in the cracks of cork, among them large quantities of the bacteria of vinegar; consequently, vinegar generators filled with cork are very quckly acidified.

LEATHER SCRAP.

The leather clippings or shavings are worked up into artificial leather, used for welts, heels, etc., in the manufacture of shoes.

The process of manufacture is extremely simple. The scraps are placed in square layers with the addition of an adhesive, pressed in the hydraulic press, dried and rolled. It stands to reason that this leather is only suitable for light work, and cannot be used in the wet.

The method of manufacture employed by Sören Sörenson, of Copenhagen, is as follows: If the scraps are in an impure state, they are first freed from all foreign substances, and are then worked up in a specially-constructed machine into a homogeneous material with the fibers separated. If the leather after being finely divided in this way is mixed with liquid ammonia, a gelatinous mass is produced, which, when pressed in molds or rolled out into sheets, forms a very hard and stiff product, possessing remarkable cohesive power, but no elasticity, and which is soluble in water. To render it elastic and to resist the action of water, it is mixed with India rubber. The rubber—any kind may be used, from the finest Pará to the most ordinary African—is crushed and washed in a washing machine consisting of two grooved steel rollers; a stream of water is directed against the latter, serving the double purpose of cleaning the rubber and protecting it from being ignited in consequence of the powerful friction. After the washing process the rubber is dried, cut up into small pieces, and dissolved by means of turpentine oil, benzine, carbon disulphide, or other suitable solvents. The quantity of the solvent used depends upon the quality of the rubber. Pará rubber can be dissolved, or rather sufficiently swollen in bulk, by 4 parts of the liquid, Central American scrap by 3½ parts, Guayaquil rubber by 3 parts, and African by 2½ parts. After the rubber has been treated in this manner, it is mixed with the ammonia and well stirred. Then the prepared leather is added in a tightly-closing kneading machine. The mixing proportions vary according to the quality of the product desired. For soles, 25 parts solid rubber, 67 parts ammonia, and 67 parts leather; for heels, 25 parts rubber, 80 parts ammonia, and 80 parts leather; for insoles, 25 parts rubber, 75 parts ammonia, and 90 parts leather. After the kneading, which is continued until the mass is completely uniform, as it is dried it is subjected to various progressive pressings, the intensity depending on the purposes to which the different products are destined. The greatest pressure, nearly 6,500 pounds per square inch, is applied to leather intended for soles. When the pressing process is completed, the product is colored, varnished, or otherwise treated to give it an appearance as similar as possible to that of natural leather.

Smith and Johnson, of Huntington, dissolve the scrap in sulphuric acid, wood vinegar, and fusel oil; they then add melted wax and mix the whole thoroughly with paper pulp, likewise previously impregnated with melted wax. The compound is then dried, crushed, steamed, and pressed into the required shape. Leather prepared in this way is said to be waterproof and extremely durable.

Leather treated by the following process, described in Ackermann's "Gewerbe-Zeitung," yields a product which, with the same thickness as ordinary leather, is quite as pliable, durable, and useful as the latter, but more waterproof. The mixture consists of 1 pound India rubber to 3¼ pounds leather scrap of any kind in the form of rasp chips. To combine thoroughly the two substances, the rubber is dissolved in benzine or carbon disulphide; when dissolved, 1 pound of ammonia is added, and the whole well stirred. A grayish white rubber will then be precipitated. The leather scrap is now gradually kneaded into the resulting pulpy mass. When the whole has been rendered homogeneous, the stiff paste can be rolled or pressed into sheets, cords, tubes, rings, lining for cold water pumps, flanges, etc. This substance is always preferable to vulcanized rubber or leather alone.

Leather scrap can also be used for making artificial ivory veneers. These are said to be made of the bones of goats and sheep and of leather scrap from calf and deer skins. The bones are treated with calcium chloride for ten to fourteen days, then washed in clean water and dried. When this has been done, the bones and the leather scrap are placed in a boiler and dissolved by steam, forming a liquid mass. One-quarter of a pound of alum is added to 10 pounds of the liquid and well mixed; the froth which forms on the surface is then removed until the mass is quite clear. After this, the desired colors are mixed with the mass while the latter is still tepid, whereupon it is strained through a clean linen cloth and poured into a suitable mold, to be left until properly cool, so that the molded mass can be placed on a frame covered with linen and dried in the air. As soon as it is quite dry, it is pickled for eight to ten hours in cold alum water until it acquires the proper hardness. In this pickle, ½ pound of alum is used for 1 pound of the veneer. When the latter is removed from the pickle, it must be washed in fresh water and dried on the frame already mentioned.

H. P. O. Lissagaray has patented a process for making assimilable manure from leather scrap. The scraps are immersed for about five minutes in water, to which about 10 per cent of concentrated sulphuric acid or sulphate, such as alum or manganous sulphate, is added, and dried, first in the open air and then in a current of hot gases. The substance becomes quite brittle from this process, and can then be easily triturated to a fine powder in any kind of mill.

*Leather Scrap in the Manufacture of Glue.*—In connection with the utilization of leather scrap in the preparation of glue, an apparatus for cutting up the scrap has been constructed by J. Repp. The cooled material is well divided in this simple and easily-worked apparatus and is at the same time washed clean, so that it is then ready to be made into glue. The apparatus gives excellent results, as, owing to the continual influx of clean water, the cleaning and cutting up of the leather is performed more satisfactorily than by the earlier processes, in which the leather was first let into the water in large baskets on a hoist and then cut up when nearly dry.

Leather tanned with a substance insoluble in water, such as chamois and similar tanned leather, is not adapted for making glue, and requires a difficult preliminary treatment, which, however, is well worth the trouble. With tanned leather the manufacturer has to be careful that all tannic acid is removed from the animal tissues, since even a small quantity of this substance deprives the tissues of their solubility in water, and hence of their capacity of being made into glue. Above all, the scraps must be divided as uniformly as possible.

When the scraps have been treated in the manner described and thoroughly washed, they are subjected to a chemical process. Stenhouse uses a boiler with a pressure of two atmospheres for this and adds 15 per cent of slaked lime, well diluted with water, to the leather mass.

For eliminating the tannin, some use caustic soda, with which the leather pulp is boiled for twelve hours. After boiling, the water is drained off and the paste pressed out and reboiled with soda of the same concentration. The soda is again carefully washed in the stuff engine. If the soda lye is neutralized in the liquid taken off after the first boiling, it can be utilized for tanning or as tannic acid for other purposes.

Jones Bergmann, of Neubidschow, has published the following process for utilizing the greased waste products of leather manufacturers and curriers:

The top is removed from an ordinary cask, preferably one of hard wood; the cask is then placed upright, with the open end uppermost, and a second, perforated bottom inserted in it at a height of 6 inches above the other bottom. A steam pipe 0.5 to 0.8 inch in diameter is introduced into the cask from above; it extends as far as the perforated bottom and is provided, above the cask, with a valve for regulating the steam supply. The scraps are poured into the cask to a third of its height, the valve opened, and steam introduced until the scraps, which should be stirred two or three times during the steaming process (lasting about 14 minutes), are thoroughly seethed; this may be ascertained by their taking on a dark brown color. The grease contained in the scrap is liberated by the action of the steam, and appears on the surface of each piece. The water condensed from the steam collects between the two bottoms, and can be drained off through a discharge cock when required.

After this process the scraps are immediately taken out of the cask with a fork and wrapped in pressing cloths of equal size, forming layers each 1 to 1½ inches thick. The scraps with the cloths round them are stacked in an upright screw-press with previously-heated metal plates in such a manner that every layer of scrap has a metal plate over it, and ten or more layers, according to the capacity of the press, lie one above the other. When the plate attached to the spindle descends, the grease is pressed out of the scrap and flows off so long as it is not rendered pulpy by cooling; this can be retarded by placing a double bottom under the lowest plate of the press and keeping it constantly hot by steam. As soon as the fat has ceased to flow the screw is reversed, the pressed cakes removed, the cloths taken off, and the cakes dried. The grease obtained by pressing is absolutely pure, not having suffered any deterioration through the addition of chemicals, and can be immediately used again for greasing skins and hides. It is also, as a matter of fact, better than fresh grease prepared from tallow, degras, or blubber, since portions of resin or other injurious substances, liable to be present in these latter, are removed by the foregoing process. The dried pressed cakes are now ground, and form an excellent artificial manure. This manure can be employed without the addition of any other substance, and meets with a ready sale.

## A NEW WAY OF MAKING PHOSPHORUS.

UNTIL recently, phosphorus, which is used chiefly in the manufacture of matches, was made solely from bones and organic substances. There is something gruesome in the thought that illumination should have come to us by way of death, but the fact remains that only since the perfection of the electric furnace have natural phosphates been used to any extent in making phosphorus. The extraction of phosphorus from mineral deposits brings the industry within the scope of the investigations made by the United States Geological Survey, and the forthcoming number of the annual volume popularly known as the "Economic Bulletin" will contain an article by Mr. George W. Stose, on phosphorus ore at Holly Springs, Pa.

At the foot of the northern slope of South Mountain, in the vicinity of Mount Holly Springs, about ten miles southwest of Harrisburg, a deposit of wavellite occurs in the white clay associated with manganese and iron ores. Small quantities of phosphorus had previously been obtained from phosphorite and from apatite, but wavellite, which is aluminum phosphate, has never before been used commercially in the manufacture of phosphorus, as the mineral generally occurs in very limited quantities.

The clay in this region is extensively mined as a filler for wall paper in the vicinity of Mount Holly Springs, and prospected for everywhere along the mountain front. It was in one of these prospect pits that peculiar round white nodules were found in the clay. The less weathered of these, when broken open, show a beautiful, radiate, silky, fibrous structure. It proved to be wavellite, a rather uncommon mineral in so pure a form, and not known to occur elsewhere in sufficient quantity to be mined.

A company was organized by Philadelphia capital to develop the deposit, and a mill for the extraction of the phosphorus from the ore was built near the mine. The mine was opened in 1900, the first years being devoted to prospecting and experimenting with the reduction of the ore. During 1905 the mine was in active operation and 400 tons of ore were reported to have been extracted and reduced in the company's furnaces.

The Readman process, patented in 1889, is the one that has come into commercial use in most countries.

The world's production of phosphorus has been variously estimated to be from 1,000 to 3,000 tons a year. The greater part is made in the Albright and Wilson factory, Wednesfield (Oldbury) England, where the Readman process originated. Other large factories are located at Lyons, France, and at Griesheim and Frankfort, Germany. There is also a plant in Sweden, and there are numerous smaller ones in Russia.

The census of 1900 in the United States reported three phosphorus establishments in operation, but the census of 1904-5 reported only the Oldbury Electro-Chemical Company, of Niagara Falls. It was impossible to learn the production of these companies.

## A STUDY OF COLOR PHENOMENA.

EVEN when the lighting of an object does not vary, the color of the object is perceived differently according as the eye has been previously exposed to the light or not. If the eye has been exposed for two or three minutes to the action of the light, or if it is placed near white surfaces which reflect it, it adds, so to speak, a blue-green tint to all the colors which it perceives. Here a white of a slight pinkish hue becomes a pure white, while the greens and blues gain in brightness and the reds, oranges, and yellows lose their character. A yellow-green tint equally distant from yellow and green becomes green. A like tone equally spaced from red and blue turns toward the blue. We observe these differences of perception very well according as the eye is lighted by different methods, among others by the following, based on a remark made during a discussion at the Société d'Ophtalmologie in 1897, in which Chibret, Tscherning, and Dufour took part. They observed that if the two eyes were lighted unequally, the eye remaining in the dark perceives as pinkish-white the same white paper which the lighted eye sees as greenish-blue. The method consists in comparing at the same time the perception of a color scale by both eyes, one of which

is submitted to a side lighting while the other is free. In order to modify our perception, the rays need not enter the eye by the pupil. The iris and the other membranes of the eye are far from forming a dark chamber like a camera, but let the different rays pass. They stop the blues much more than the reds. Also the white light passing the pupil and meeting the choroid will not be equally reflected to the retina. The blue rays will be stopped while the orange and red rays will be reflected and traverse the retina a second time, in fact, so that the white or orange light or the surfaces capable of reflecting them act to modify our perception the most. Blue rays or surfaces modify this in a much less degree. It results from this that when we note the coloration of an object we should define the condition of lighting given to the eyes. Our perception comes into use in different cases. For chemical reactions, whose observation is based on coloration processes, the lighting of the eyes has some importance. For instance, the same piece of vegetable dried paper will appear red or blue according as we examine it in a laboratory with dark walls or in another with white tiled walls. As to meteorological observations, we find that the blue of the sky is partly a creation of the lighted eye. This fact has been brought out by Dr. Rémy. Starting from observations made with ocular instruments, he devised several methods for showing that the sky is not blue. When we look at the sky from the bottom of a pit or through a tube blackened inside we observe it to be much less blue and relatively white. M. Fortin shows also how to obtain the contrary effect. To give a blue tone to a white sky it is merely necessary to light one eye by an artificial light at the side. If the eye thus lighted observes the sky through a tube the latter appears a darker blue, and when the eye is strongly lighted the tint becomes very dark. When we observe the moon with one eye free and the other having a side light, the disk will appear pinkish to the first and blue-green to the second. Some of the meteorological phenomena, such as the "green ray," are due to projections of the eyes when exposed to a bright light, especially after a rapid winking of the eyelids. During certain eclipses of the sun, the moon's disk is seen as orange red. It may be that this is a phenomenon of contrast due to an exaggeration of the blue in the rest of the visual field. This would be produced after a too long and too intense lighting. The same principles come in for the examination of paintings, and the lighting of the eye has an important part, outside of the lighting of the painting. What makes the character of a painting is the intervals which the artist placed between the tones which are juxtaposed. If before coming to the picture or if at the instant we come opposite it our eyes have undergone a difference of lighting, the intervals between the colors will be modified and the idea of the picture will be different from what the artist gave it. The beauty of the frescoes which remain in place in Italy comes from the fact that they stay in the place where they are executed. When transported, it is not enough to replace them in the condition for having the same amount of light. The observer, before he looks at them and while examining them must be in the same situations as what he would have found in the original place. We remark the modifications which could thus be given to a painting by the following observations. In autumn, when the leaves of trees have a yellow-green color, they appear to be green at noon. If we leave one of the eyes for two minutes in the dark it will perceive when first opening that the landscape is yellowish, while the other eye continues to see it as green. Water contained in a white enameled basin of two feet depth will pass by all the shades from sky blue to black, according to whether the eyes have undergone the action of white light or not. At the convent of San Marco at Florence the frescoes of Fra Angelico have azure-blue tones of incomparable brilliancy in the monks' cells where three of the four walls have remained white.

## BLACK SANDS INVESTIGATION.

AMONG forthcoming publications of the United States Geological Survey will be one by Dr. David T. Day and Prof. Robert H. Richardson, entitled "Useful Minerals in the Black Sands of the Pacific Slope," which is the result of an investigation authorized by Congress March 3, 1905.

In the beginning of the investigation a circular letter was sent to all the placer miners of the United States whose addresses were known, about eight thousand in all, authorizing them to send in samples of the black sands obtained by them up to four pounds for each sample. The examination of these samples, partly in Boston, Mass., and partly in Portland, Ore., show that the following minerals, in the order named, are most commonly found in these sands. Magnetite, ilmenite, gold, zircon, garnet, olivine, and iron silicates, pyrite, chromite, platinum, iridosmium, monazite, cinnabar, corundum, and cassiterite. Other heavy minerals are only very exceptionally found.

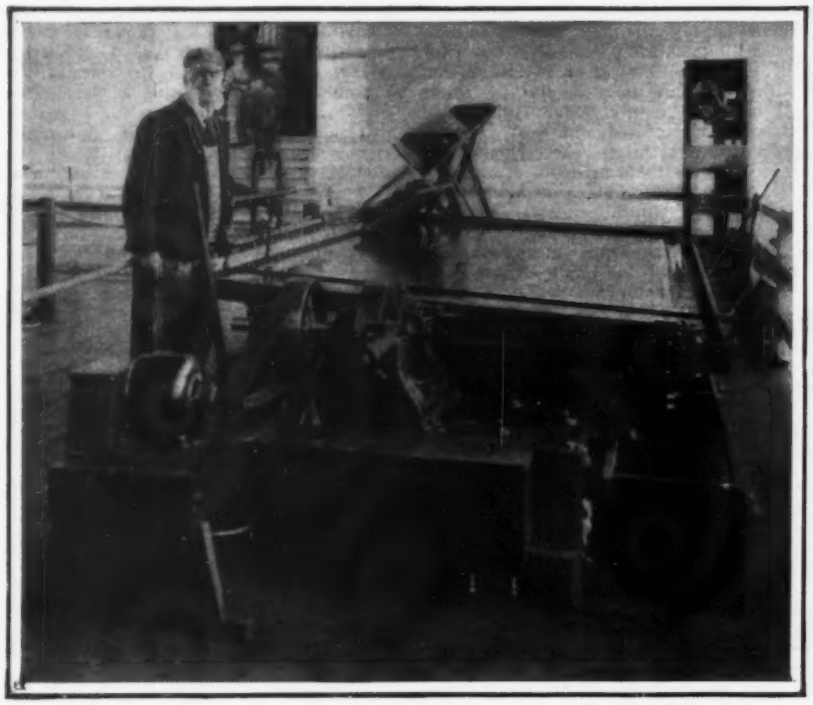
In this report the expression "black sand" is used to embrace the residual sands left in concentrating placer gravels; not merely the heavy materials left in the sluice boxes in placer mining, but also the black sands left by the concentrating action of waves and the natural concentration products of stream action.

In order to determine what minerals could be included under the title, "Useful Minerals," in these black sands, it was necessary to determine how readily they could be separated from one another by various methods of concentration. As a result, it was found that with careful sizing it is possible to separate gold and platinum from these sands with comparative ease and with small expense by the use of concentrating machines of the shaking table class, and that partial separation of various other minerals can be made at the same time, so as to render available for the market at a low cost monazite, zircon, ilmenite, chromite, garnet, and cassiterite.

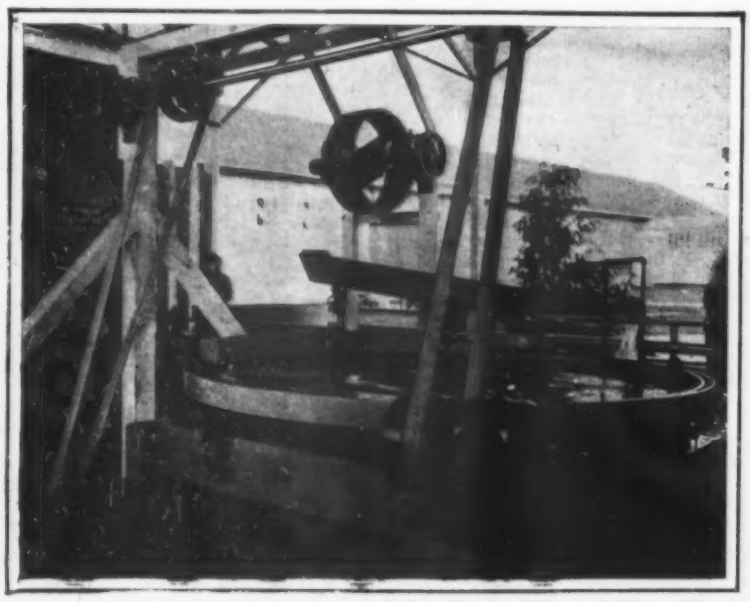
This inquiry was started primarily on account of the increasing scarcity of the world's supply of platinum. The investigation showed that platinum is found in one hundred and twenty localities, and that the largest and most profitable field for commercial exploitation is comprised in Coos, Jackson, Curry, and Josephine counties, Oregon, and in Del Norte, Siskiyou, Humboldt, and Trinity counties, California. Outside of this region platinum is also found to a notable extent in Plumas and Butte counties, California, and, although the proportion of platinum per cubic yard of gravel is not so great, the large dredging operations in Butte County make this an important locality. Platinum was also found occasionally on the Snake and the Columbia rivers and on various beaches of the Washington coast. It was found in place in chromite near Anacortes, Wash., as well as at the previously known locality, the Rambler mine, in Albany County, Wyoming. It was found that the magnetite contained in the black sands of the Pacific slope constitutes a greater supply of useful iron ore than any other available source known on the Pacific slope. This magnetite usually contains from 5 to 10 per cent of titanium. It was found that this titanium offered no obstacle to the production of high-grade cast iron in the electric furnace; that in a modification of this electric furnace this cast iron could even be decarburized to a very soft steel of high quality. Facilities were not at hand for smelting this iron ore in an ordinary blast furnace.

The bulk of this report is taken up with the analyses made of the samples that were examined. A few words are added concerning the cost of concentration.

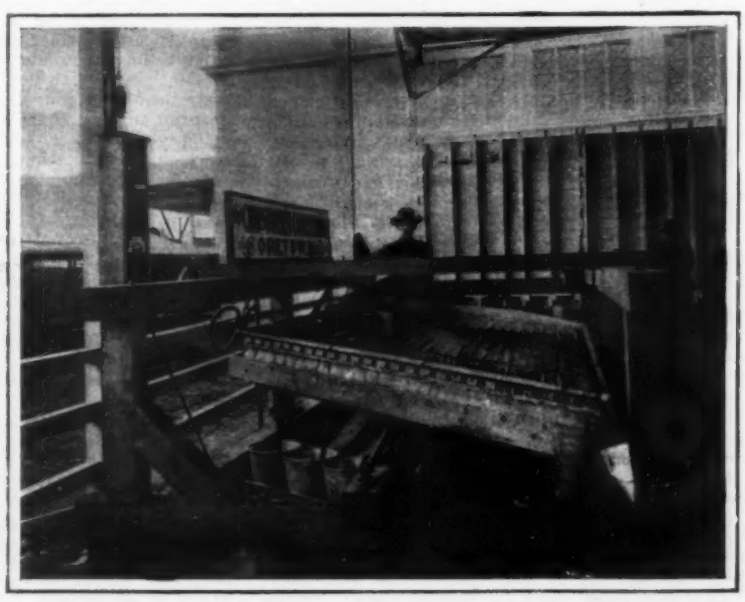
That part of the report which treats of the electric smelting of magnetite from black sands was submitted to the Senate on January 21 by the Secretary of the Interior, in response to a resolution calling for information on the subject, and ordered printed as a Senate document. The whole report is available as a separate chapter of the volume "Mineral Resources of the United States, 1905," and may be obtained on request sent to the Director of the United States Geological Survey, Washington, D. C.



MOTOR-DRIVEN CONCENTRATING MACHINE FOR HANDLING LOW-GRADE GOLD DEPOSITS.



CIRCULAR TYPE OF CONCENTRATOR FOR REFINING BLACK SAND.



CONCENTRATOR IN USE FOR EXTRACTING GOLD FROM BLACK SAND.

BLACK SANDS INVESTIGATION.

## THE VIAGRAPH.

THE demand for good roads increases with the steady growth of automobile traffic. Bad roads not only cause frequent accidents to automobiles, but they are made worse by the swift and heavy machines which aggravate the inequalities of the surface. Hence some means of recording graphically the inequalities of a roadway would be very useful to roadmasters. For this purpose an English engineer, M. T. Brown, has devised the viagraph, an instrument which automatically traces on a band of paper every inequality and defect of the surface over which it is drawn. Externally the viagraph resembles a long and narrow sled. The recording apparatus is placed between the runners and is protected by a glass cover. A toothed wheel which turns freely on the end of a horizontal lever is pressed downward by a spring so that it rolls on the road and follows every elevation and depression.

The lever acts, through an adjustable link, on a second lever placed above and nearly parallel to it and the free end of the second lever carries a writing point which presses against a band of paper carried by a vertical drum. The band is unrolled from a spool, passes over the drum and is coiled up on a second spool by the motion of the sled itself. For this purpose the axis of the toothed wheel already mentioned bears a bevel wheel which engages with a second bevel wheel on a shaft parallel to the levers. An endless screw on the other end of this shaft engages with a toothed wheel on the axis of the drum, around which the band of paper makes a half turn. Hence the paper moves and stops with the sled, and the writing point, moving up and down, according to the elevations and depressions of the roadway, makes a trace of the profile of the surface in which the inequalities are more or less exaggerated according to the adjustment of the link which connects the two levers.

A cord connects this recording apparatus with another recorder of the integrating type which indicates on three dials the whole distance traveled by the road wheel, including all the inequalities of the path.

Inside the paper drum is a gong and a hammer which is tripped and caused to strike the gong, once in each revolution of the drum, by a projection on the inside of the latter. If the levers are so adjusted that each revolution of the drum and, consequently, each stroke of the gong indicates one kilometer of progress on a perfectly smooth road, the gong will sound for each kilometer traveled by the wheel on a rough road, including the inequalities, and therefore at shorter intervals of distance measured along the road. In this way the average roughness of two roads can be compared.

The viagraph gives accurate and trustworthy results when properly used, but it requires intelligent management. It should be drawn with a long cord to avoid lifting the forward end and several tracings should be made with it of each section of road and the mean value of the results taken.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Umschau.

## TYPES OF EARLY STEAM ENGINES STILL WORKING IN ENGLAND.

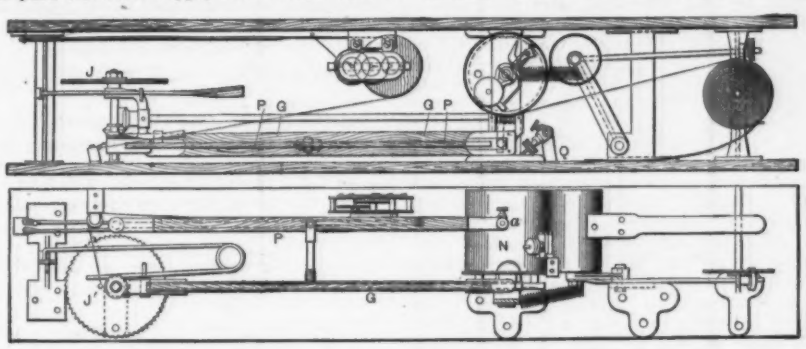
By the English Correspondent of SCIENTIFIC AMERICAN.

NOTWITHSTANDING the remarkable and far-reaching improvements that have been effected in the design of the steam engine since its inception in the middle of the seventeenth century, and the stage of economy and efficiency to which it has now been evolved, there still remain in actual operation to-day in Great Britain a few plants installed over one hundred years ago, and which are practically the same to-day as they were when first set up. In the majority of cases their retention has not been actuated by motives of financial inability to procure a modern type of power-producing plant, but simply because a more economical design is not available for the class of work that these ancient engines are required to fulfill. These isolated links with the early days of steam engine practice as followed by Newcomen and Watt afford interesting object lessons of the remarkable strides that have been made toward efficiency and economy, more valuable than mere examination of the relics of the museums, since they may be seen actually at work, accomplishing a specified object.

At the present day the number of ancient Newcomen atmospheric engines still in service in Great Britain may be numbered on the fingers of one hand. Up till a few years ago examples might have been seen at a few of the oldest mining centers in the north of England; but when the plants of these mines were overhauled for the purpose of bringing them more into line with modern conditions, the cumbersome machines which had proved so faithful for a hundred years or more were "scrapped," or withdrawn from operation. An excellent specimen of Newcomen's invention, however, may be seen working to-day at a large colliery near Glasgow, said to be one of the oldest engines now at work in the world, with all its former features and parts retained. It was erected at the colliery in 1809, and has been working daily ever since.

Inasmuch as this engine was constructed some years after Watt had invented the separate condenser, it is somewhat curious that the type which it superseded should have been preferred, Watt's engine having successfully overcome many of the inherent disadvantages of Newcomen's machine. This step is believed to have been influenced by a desire to escape payment of royalty. Moreover, strange to say, unlike all the Newcomen engines of which there is a record, this plant is a pumping and not a winding engine.

The beam is approximately 17 feet in length, and the flywheel about 15 feet diameter. The cylinder is 3 feet 6 inches in diameter, and has a stroke of 6 feet. It is of the pure Newcomen type, but is fitted with a




THE OPERATIVE MECHANISM OF THE VIAGRAPH.

modified Watt parallel motion, with the radius bar above the beam, the crank and flywheel being comparatively modern. The cylinder has never been bored, yet it has a beautifully clean and smooth internal surface and has worn out considerably more than a thousand packings. Hemp gasket is used for packing the piston, steam-tightness being secured by means of a layer of water carried on top. There is no automatic valve gear, an operator opening alternately the steam and injection valves by means of a single lever. Neither is there an air pump. The condensed steam and injection water are ejected by gravity and the pressure of the incoming steam through a flap foot valve. The beam, which is carried on a masonry pier, works a feed pump.

Despite its age and comparatively primitive nature, the engine works smoothly and steadily. The period occupied in raising coal from the bottom of the pit to the surface is about thirty-five seconds. Except for the renewal of a few trivial parts such as brasses and spur wheels, which have been accidentally broken, the engine has cost practically nothing to maintain, and no important part of the machine has ever been renewed. The engine is considered eminently suited to the intermittent work it has to accomplish, and is stated not to be so wasteful as might be supposed.

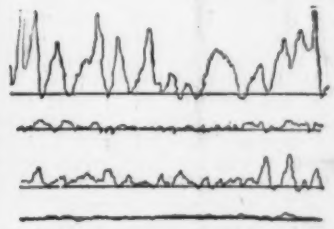
Another interesting relic of ancient steam practice may be seen at the Fazely Street mills in Birmingham, where thirteen heavy rolls are driven by an engine erected in 1760 or thereabout, the precise date not being known. These mills are said to have been built for the purpose of operating Wyatt's invention for spinning cotton by rollers—an anticipation of Arkwright's invention. Wyatt's first motive power consisted of two donkeys, but in the mill that was subsequently erected, this animal power was superseded by the steam engine in question. Precisely at what date the engine was erected is not known; but according to the records of the works and the various researches that have been made by the present descendants of the original proprietors, 1767 is the date generally accepted. It is also asserted that the engine was erected by Pickard, probably the James Pickard who was associated with Washborough, of Bristol, who secured the patent in 1778 for "converting rectilinear into rotative" motion by means of a crank, to the intense disgust of Watt, who was experimenting in the same direction and had achieved success when he found himself anticipated by Washborough, and in consequence evolved and patented the "sun and planet" motion. The early history of this engine is unfortunately wrapped in confusion. As a consequence, it has more than once been the pivot of animated discussion. It is stated, for instance, that originally the sun and planet motion was used with the old flywheel, and if such was the case it cannot be so old as 1767. It is generally believed, however, that in the first instance some other device was used, and that this was subsequently superseded by Watt's more efficient invention.

SHOWING HINGES WHICH PERMIT RUNNERS TO FOLD BACK FOR EASY TRANSPORTATION.

ON THE ROAD.

GETTING READY FOR A TEST.

TESTING A PAVEMENT.



TRACINGS FROM DIFFERENT ROADS.

THE VIAGRAPH: A ROAD-TESTING MACHINE.

Unfortunately, many repairs have been made, of which there is no record prior to 1903. At that date the engine was working up to 120 horse-power, driving thirteen sets of rolls with the original built-up oak beam, 28 feet in length by 3 feet thick, and 2 feet wide, together with the original connecting rod, 30 feet long, and weighing 15 tons. The beam was fitted with a counter-weight to assist the ascent of the piston. The cylinder is 51¼ inches in diameter, and bears the inscription that it was cast at Coalbrookdale on August 2, 1802. This is not believed, however, to be the original cylinder, supplied with the engine when it was erected.

According to the investigations of Mr. G. Stokes, to whose courtesy the writer is indebted for much informative history concerning this old relic, there was formerly in the employ of the mills an operative who fifty-five years ago remembers seeing in the yard an iron beam which had been purchased forty-four years previously to replace the oak beam. This takes us back to nearly a century ago and evidently the engine was then in working order, because a reserve beam was procured in case of a breakdown. As, however, the wooden beam showed no signs of deterioration, the iron beam was resold to Watt & Co., from whom it had been originally purchased as a reserve.

It is stated in certain quarters that this engine was built by Watt, and that it was the famous "No. 4," familiarly known as "Old Bess," erected at the Soho foundry of Boulton & Watt. But the firm at whose works the engine is now working, and by whose ancestors the machine was acquired, have evidence which refutes this contention. When a new cylinder was required, it was procured from Coalbrookdale. Had the engine been built by Watt & Boulton, the new part would certainly have been obtained from their foundry at Soho. Moreover, it is scarcely possible that Watt, who had been deeply incensed at Washborough's forestalling him in the crank, would have employed Pickard, who had been associated with Washborough in his invention. Whatever its date, the engine is in operation at the present day, and is giving complete satisfaction. A year or two ago it was completely overhauled. Though frequent alterations and additions have been effected in its design, the fundamental portions which serve to identify it with the earliest days of steam engine practice are still existent.

In Cornwall, the cradle of the British mining industry, whence many of the early exploiters in steam engines hailed, may still be seen working to-day some highly interesting old relics. The pumping plant at Redruth comprises a single-cylinder horizontal steam engine geared down to a shaft on the end of which is the outside crank. Two rods are connected with this crank, one extending to the left and driving the pump and the other to the balance box. In the case of the pump the horizontal arm carries a rod at its end, which descends the shaft actuating the pump. As the crank revolves, this rod is moved up and down, the balance box also being alternately lifted and depressed. The latter is filled with scrap iron, rubble, and stones. As pumping is done on only one stroke, the balance box is so connected that the engine cannot race on its unworking stroke.

Near St. Austell an example of this system of pumping is to be seen in conjunction with a large condensing beam engine, dated 1841. Although this plant is by no means so old as those already described, yet it serves to illustrate the primitive steam engines in vogue some seventy years ago. The St. Austell engine is used for stamping as well as pumping, and although the plant is placed some distance from the stamp, a direct drive is used.

In the Redruth district may also be seen the only remaining survival in the country of the earliest days of railroad practice. It is a curious system adopted in the early years of the nineteenth century, primarily as a horse road, but later adapted to steam traction. The gage is 4 feet, but the line runs through very difficult country, the gradients being very steep. Because of financial difficulties the company is not in a position to relay the track, so that the road is in practically its original condition, with light iron rails spiked to large blocks of granite. The rolling stock includes three engines, of which, however, only one is in use at one time, the railroad being at present used only for freight traffic. Two date from 1854, and the third from 1859. They are all saddle-tank engines, with the tanks flat on the top and sides. Although the engines have been somewhat modernized from time to time, they still bear traces of their original design. One has a boiler with the haystack type of domed firebox working at a pressure of 120 pounds per square inch. Although this design is now quite obsolete, yet it possesses many interesting and excellent points when worked at the requisite pressure, but they fell into desuetude as higher boiler pressures came into general adoption, so that now these engines constitute unique survivals of the early steam-engine days.

## GEAR RATIO, WEIGHT, AND MOTOR CHARACTERISTICS.

"THERE is just one gear ratio which is best for a given weight to be propelled at a given speed by a given motor. Anything either side of this is not as good and entails unnecessary loss. This applies as well to the gasoline motor as it does to the electric.

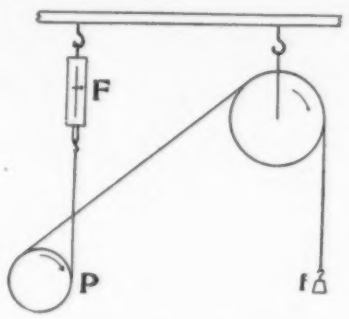
"A clear understanding of what is involved in determining the best gear ratio and motor characteristics for a given set of conditions is, therefore, a matter of considerable importance to both builder and user, especially since standard motor equipments, both gasoline and electric, are coming to be used under widely varying conditions of load, speed, and service, and in many cases quite outside the control of the builder."

This subject, which is discussed at some length in Motor Traffic, by Hiram P. Maxim, is one that is not generally understood by users of motor vehicles. The discussion is accompanied by diagrams and tables of motor characteristics, based on specific conditions.

## TO DETERMINE THE HORSE-POWER OF A SMALL STEAM ENGINE.*

By C. H. PERRINE.

ONE of the most popular experiments in the physics work in schools is the determination of the horse-power of a toy steam engine. A brief bulletin is prepared for the students which embraces the following outline:




Method: Set up apparatus as indicated in drawing. Measure the circumference of $P$ (engine pulley). This can be done sufficiently accurately by use of string, getting the length of one turn or loop. Put a small weight at $f$ to hold the string taut. Having supplied the boiler with plenty of water, place the Bunsen flame in proper place and start the engine. Vary the load at $f$ until the speed is sufficiently slow to count accurately. The actual friction load which the engine is pulling, is the difference between that registered by the spring balance $F$ and the weight $f$, which is used to vary the friction.

Data required: Circumference of pulley $P$ in feet, reading of $F$ in pounds, weight of small $f$ in pounds, and revolutions per minute, then

$$\text{Horse-power} = \frac{(F - f) \times (C \times \text{R.P.M.})}{3300}$$

Repeat the test when the engine is loaded to its maximum. Increase the load as before by varying $f$.

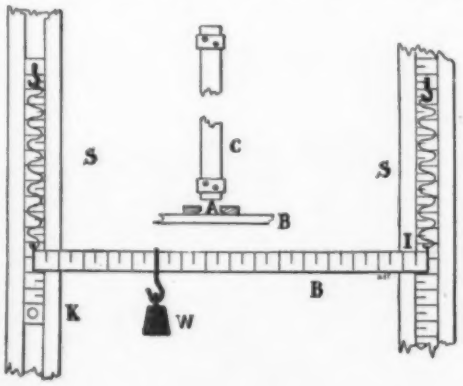
The results are very satisfactory. The same process is used in determining the horse-power of an electric motor or a water motor.

## A SIMPLE APPARATUS FOR PARALLEL FORCES.*

By DEFORREST ROSS.

THIS piece of apparatus is designed to overcome an element of error in the experiment of the composition of parallel forces. When the two draw-scales, or coiled springs, used to represent the two forces, are attached to fixed supports there is but a single position for the point of application of their resultant such that the bar will assume a horizontal position; and when the bar assumes an inclined position, the forces are no longer acting parallel with each other, and this inclination is considerable, if the springs are quite sensitive, the nearer this point approaches either of the other forces.

The accompanying figure illustrates a means of overcoming this difficulty, and needs but little explanation to make its action clear.




The spring $S$ is fastened to a scale which can be raised or lowered as the occasion requires, and held in position by means of the set-screw $K$. $C$ is a back view of this sliding scale showing the two brass plates which project beyond the edges and slide in grooves in the uprights, shown in $A$, thus holding it in position and at the same time admitting of a free and easy movement. A scale, not shown in the figure, on each upright, enables the student to readily bring the bar into a horizontal position.

The piece is simple, inexpensive, and gives good results.

* School Science and Mathematics.

## A FEW PROBLEMS OF THE PRESERVING INDUSTRY.*

By DR. E. KRÜGER.

THE preserving of vegetables, meat, fruit, etc., embraces principally its preparation for immediate consumption, and its preservability. However simple these matters may at first glance appear to be, they offer in actual practice very serious, and up to the present, but little explained difficulties. These difficulties are intensified, because many factories, in the desire not to surrender their factory secrets, have made an interchange of opinions and experiences utterly impossible. On the other hand, we have here a field which is still open to active, interesting, and scientific research and treatment; besides, more and more frequently preserves are being placed before the food chemist for examination whose spoiling he finds great difficulty in explaining, without a better knowledge of their method of preparation. I shall therefore endeavor in the following paragraphs to throw light on the various problems which present themselves in the technique of this industry, by means of an outline of the methods of processing. As it is the preparation of preserves in cans after the method of Appert which principally engages the special interest of the chemist, I shall in this article confine myself to this particular field.

Before the fruits, vegetables, meats, etc., are placed in the cans they are boiled off for a certain length of time, depending on the kind of fruit, etc., and its quality, in a kettle (up to the present, usually made of copper); then they are "blanched," as it is called. This expression probably originated in the boiling of asparagus, which in this part of the operation is mostly bleached with $SO_2$, citric acid, etc. The "blanching" effects a cleansing of the vegetables, takes away their disagreeable herbescent taste, and softens them to such an extent that they can easily be filled into the cans. Particular attention must be given to the condition of the water, mainly as to its being free of iron, on account of the discolorations caused by iron. It was on this account that aluminium kettles, made according to the welding method of Heraeus (German patent No. 118,868), were adopted in place of the formerly used copper kettles. Information as to the utility of aluminium has not yet, to be sure, been gathered to any considerable extent. At the time of "blanching" the vegetables are, if necessary, colored (peas, for example, with $CuSO_4$), and are then, after being quickly cooled, filled into cans. Allowing them to remain exposed to air for any length of time, particularly while in a warm condition, frequently exercises a prejudicial influence on the color; asparagus, for example, turning yellow, etc.

The cans are made of sheet iron with a thin coating of about 2 to 3 per cent of tin, which, on the whole, has proved itself durable and otherwise satisfactory; in many cases, however, especially in fruits whose high content of acid works as a solvent, the practice has been followed of lining the inside of the cans with a lacquer (copal, etc.) Many and special demands are made of this lacquer, which lacquers up to this time have been far from satisfying. It should be capable of resisting comparatively strong acids, adhere well to the sheet iron, and above all, it must not get brittle, because otherwise, when in the preparation of the cans it is subjected to a strong pressure, it would break with great ease at those points where sharp concentric grooves are pressed into the covers for strengthening the can. It is just at these grooves that the can is generally corroded. Many lacquers dissolve slightly, and give off rather a sharp taste to the contents of the can. The method of closing the cans has undergone a complete revolution in the last few years, the soldering method being replaced by the overlapping crease and stamp method. Whereas by the first method the cover was merely soldered on the can, which took time, was expensive and uncertain as well, the creasing method consists in a folding together by means of appropriate machines of the cover on top with the somewhat bent (turned toward the outside) rim of the can. Air-tightness is achieved by means of a rubber ring laid in between. A substitute for this rubber ring is being searched after continually; for example, in the adhesive gum of impregnated celluloid. The closing itself has proved efficient in all respects, and it would doubtless be difficult to substantially improve the principle. Quite the contrary with the manner of opening the cans, which up to this time has been done with a knife working on the lever plan. Its fulcrum, in the form of an appendage or roll of metal, is carried along the upper edge of the can, whereas the knife itself cuts into the cover, or rather into the edge of the cover. The method of opening the cans has indeed become a painful and troublesome point for the preserving industry, after people tried to attribute injuries to health, especially the frequent occurrence of typhlitis among the masses, who are the principal users of preserves,† to the shivers of metal which find their way into the contents of the can in opening it. From the medical‡ and chemical§ standpoint, this question has now been answered, that injury to the health by shivers of metal need not be feared. Nevertheless, these opinions have led to a flood of new methods of can-opening, which have culminated in various German patents, of which probably the most important is the principle of the previous weakening of the cover by a groove, which

* Pure Products.
† Max Schmidt, Altoona. Das konstante Vorkommen von Metallsplitter.
‡ Kons.-Zeit., 1906. p. 370.
§ Kons.-Zeit., 1906. p. 117.

by a sharp pressure can then be lifted off (Lubeka-werke German patent), and also the double stripe-like incision of the cover, with a tongue soldered on, for the ripping open of the can.

The closed cans are sterilized in autoclaves, and if possible a low temperature is applied, in order to avoid decrease in quality by too high a heating. On the other hand, in the desire to keep the temperature low, the danger of a defective sterilization is open, which latter is a very common and usually unexplainable occurrence. It has been sought to attribute this to various circumstances, principally artificial dunging. It has, however, been shown* that in all cases in which artificial dunging could have had a share, the spoiling did not originate in pure chemical action, but was a result of the activity of bacteria, to which possibly a favorable nutrient field for development has been given, through artificial dunging whether in the ground or in the fruit. But still other forces contribute to the sterilization. It is very important that the steam forced into the autoclaves should completely displace all the air, for otherwise at a certain pressure the corresponding temperature will not be obtained. Large cans require a longer time for thorough heating than small ones; closely packed cans are heated with greater difficulty than loosely packed ones; the inner temperature is frequently, in comparison with the outer parts of the can, decidedly lower.† All these different considerations show that however simple the principle of sterilization may be, there are many things which in practice must be kept in mind, and which offer a fertile field for speculation. The cans coming from the autoclaves are always somewhat bulged out in consequence of the pressure from within; in cooling, however, they gradually resume their normal shape. It is in this phenomenon that the processer can see if his cans are air-tight, for in cans that are not air-tight the steam pressure would be equalized, and the cans would not swell up.

It occurs quite often that the cans remain in good condition for a long time, and then suddenly spoil. An explanation for this appears in the work of Otto Rahn: "The Influence of the Products of Digestive Assimilation upon the Development of Bacteria,"‡ in which he shows that the maximal rate of multiplication of bacteria appears in a definite concentration of elements produced by the bacteria themselves during growth. The spoiling of the preserves may generally be recognized externally, by the fact that the cans are bulged out, in consequence of the high gas pressure developed during fermentation. This "swelling" of the cans leads sometimes to their losing their air-tightness, even to their bursting, from which fact some people, in complete misconception of the true cause of this non-air-tightness, have endeavored to attribute the spoiling and swelling of the cans to infectious causes presumably finding their way into the can through these openings. The cans often burst, however, without an infection by bacteria existing at all, and this is specially the case in acid-containing fruits, where the acid undoubtedly acts on the metal of the can, forming gases which cause the resulting bursting.

The changing of the color of the preserves after sterilization is a frequently occurring calamity, the reason for which is sought among various sources. It is attributed to the iron content of the water, to prolonged standing between blanching and sterilization, and finally§ to the formation of colorated metal sulphides, which arise through the liberation of $H_2S$ under the influence of bacteria or of superheated steam on albuminoids. The latter is also claimed to be the cause of the cans turning black.

The interest of the preserving industry is just now focused on the development of the legal regulations as to the addition of coloring matters and preservatives. Since the meat inspection law has forbidden the addition of boracic acid, etc., the fight, particularly on the part of fruit-juice pressers, is now raging, to secure permission to add preservatives in the form of salicylic acid.‖ The argument advanced on the side of the processers that it would be impossible to secure the preservability of the fruit juices in any other way, is answered by the statement from the other side that salicylic acid is injurious to health. On the same ground, opposition is directed against artificial coloration, peas, for instance, colored with a slight amount of $CuSO_4$, which gives them a deep green color. After the epoch-making work of Pavlovs, of Petersburg, on the digestive enzymes and the rate of time of the secretion faculty of the stomach, showed the great significance of the appearance of the food and its influence on the quantity of enzymes secreted through self-stimulation of the stomach, a change of the regulations now in force to more modern regulations would seem to be in order, both in the interest of the people and of the industry.¶

In the estimation of all these additions for beautifying purposes, after the injuriousness to health, the opinions as to the possibility of a deception on the public of bad quality goods for superior brands are to be given consideration. Justification for this deception is often disputed, in that it is considered of subordinate importance in the necessities of the business.

A great difficulty for the food chemist lies in the estimation of the quality of preserves. For this purpose, the subjective proof by taste must, alas! still be used as a criterion, for analysis according to the Weender method (protein, fat, and ash) gives us as good as no facts of importance in this direction. To be sure, with experts the proof by taste gives unanimous results;* hence use can be made of their services in those cases, where only slight differences in quality are in question.

Having endeavored in the foregoing lines to give a sketch of the present state of the manufacture of canned preserves, I hope that they will, perhaps in some points, stimulate experimental treatment of many of the problems which present themselves. I will postpone entering into a discussion of further preserving methods until after completion of certain investigations specially touching these matters.

* E. Krüger, Kons.-Ztg., 1906, p. 435.
† K. Huber, Kons.-Ztg., 1906, p. 252; E. Krüger, Kons.-Ztg., 1906, p. 545.
‡ Zentralbl. Bakt. II., Abt., 1906, Bd. XVI., p. 417.
§ The Canner, June, 1906.
‖ Kons.-Ztg., 1906, p. 430.
¶ Kons.-Ztg., 1906, p. 515.

## PHOTOGRAPHIC NOTES.

*The Lippmann Process of Direct Color Photography.*—An essential step toward the popularizing of this, the only practicable direct process of color photography, is the commercial fabrication of the necessary plates with a structureless gelatine emulsion. These plates are now manufactured by the Kranseder plate factory in Munich, in accordance with directions prepared by Dr. H. Lehmann. These plates are essentially different from those previously prepared in their color sensitiveness. Lippmann, Neuhauss, Valenta, and other previous experimenters have so mingled the dyes used as color sensitizers that equal sensitiveness for all parts of the spectrum was the result; Lehmann uses such quantities as to obtain the maximum sensitiveness for each region, especially for the red, which was not hitherto esteemed desirable. On this account a compensating filter must be used to equalize the sensitiveness. For this he uses a cell 5 millimeters thick, filled with a dilute solution of cyanin, erythrosin, and esculin (Eder's Jahrbuch, 1906, p. 51) or a dry filter of analogous absorption.

A noticeable degradation of color in Lippmann photographs is caused by surface reflections. This is usually avoided by dipping the plates in benzol or cementing on the surface a polished glass plate. Lehmann describes a third means in the Photographische Mitteilungen, 1906, p. 525, the producing of a matt surface on the film, which also removes from the pictures the shimmering, ghostly appearance which they have been wont to present.

Another important innovation of Lehmann's, if it prove sucessful, is the replacing of the mercury mirror by a mirror of polished sheet metal, which is coated with a thin layer of gum and then flowed with the emulsion. The film is stripped after development and mounted in the usual manner.

The time of exposure for the new Kranseder plates, with an objective working at f/3, and a sunlighted landscape, is only three minutes, approaching the sensitiveness of ordinary photography at its first appearance.

The question of the permanence of interference photographs does not appear to have been raised. Now Coustet (Photo. Gazette, 1906, p. 203) states that these pictures are very apt to tarnish because of the extreme fineness of the precipitated silver. The thinnest portions disappear first. A similar observation with regard to ordinary dry plates was made some years ago by Roberts, who recorded the disappearance of the stars of smallest magnitude in the older star negatives t[illegible]n by American observatories. In spite of this ob[illegible]vation, the Lippmann process, after long years of experimenting, may now, thanks to Lehmann, be regarded as more than a laboratory process.

*The Lumière Starch Process and Its Variations.*—The most promising discovery in recent years seems to be the Lumière starch process. This has been well described in the technical press during the past year, so we will give but an outline of it here. Briefly, very fine granules of starch are colored with three suitable dyes for color filters for a three-color process. Equal portions of the three colors are then mixed, forming a mixture which to the eye is neutral gray in color. A plate is coated with a tacky covering and the grains of starch sifted on, so that they cover it with a single layer of colored particles. These grains are about 1/2000 of an inch in diameter. An impalpable powder of charcoal is now sifted on to fill the interstices of the starch grains. The plate is now varnished and coated with a panchromatic emulsion. Placed in the camera glass side forward, it furnishes its own color screen, and exposure produces a color picture with a single exposure. By ordinary development a negative is produced which may be printed by contact on a similar plate to produce a positive reproducing the scene photographed. A positive may be produced directly by developing, dissolving the developed silver with dilute nitric acid before fixing, exposing to light, and developing to blackness.

This theoretically very beautiful process was announced about a year ago, and the commercial production of plates was promised for the early summer. Unexpected difficulties in production appear to have arisen, however, and the plates are not yet to be had. Meanwhile other manufacturers appreciated both the merits and defects of the process, and several modifications have been published. Dr. Smith of Zürich has patented the idea of printing a trichomatic network of extreme fineness on a gelatine-coated plate to replace the starch globules, and we believe he is now producing plates thus made.

The latest proposal is that of Sr. Ramon y Cajal, of Madrid (La Photographie des Couleurs, 1907, p. 2) who has elaborated a very complex process. His idea is that the globular starch particles form a very unsatisfactory mosaic, and that cylindrical segments would be much more satisfactory. For this purpose he takes very fine fibers of silk or wool and dyes them in aniline colors insoluble in alcohol. The dry fibers, orange, violet, and green, are mixed in the proper proportions, and immersed for twenty-four hours in a syrupy collodion solution, which holds in suspension fine particles of black or gray coloring matter. The fibers are then taken out, compressed in parallel position, and plunged into alcohol to coagulate the collodion. The solidified mass is now cut with a microtome into films about three hundredths of a millimeter in thickness, which are applied to the plate, and covered with the emulsion. The diameter of the particles of the mosaic, when formed of silk, is from five to eight thousandths of a millimeter; wool fibers are three times as thick. The cutting is effected with a special microtome, and films 20 x 25 centimeters have been made already, with no reason appearing why much larger ones could not be prepared if desirable. This will undoubtedly be an expensive process, but offers fair possibilities of commercial success.

* Kons.-Ztg., 1906, p. 516.

*Color Photographs from a Balloon.*—Prof. Miethe of Berlin has succeeded during the past summer in accomplishing the difficult task of taking three-color photographs from a balloon. He detailed his experiences in a lecture before the first session of the "Fédération Aeronautique Internationale," held at Berlin October 10 to 14, 1906. Die Welt der Technik reports it as follows: The greatest difficulty comes from the necessity of reckoning with the rapid movements of the balloon, which necessitate extremely short exposures in order to get sharp pictures. In captive balloons horizontal movements are very small, while with a free balloon they are so great that time exposures are impossible. In a free ascent vertical movements need not be considered, since exposures are made only when the balloon has come to equilibrium; but with a captive balloon they are as disturbing as the horizontal motion in a free flight. The most annoying disturbance, however, is the rotation which occurs only at the beginning of a free flight, but is incessant in a captive balloon, owing to the torsion of the tether rope. Not less annoying are the pendulum-like swinging of a captive balloon, and the swaying of the balloon car caused by movements of the occupants. The photographer's task is to utilize the rare moments of rest between the dual motions of twisting and swinging and make his exposure with a fast lens and a shutter speed of at the most 1/20 to 1/10 second. For this purpose Miethe built a camera with three lenses mounted side by side, furnished with a curtain shutter, and hermetically sealed, so that neither shutter nor plate should be affected by the sand used for ballast. Two ascents were made on quiet days when the motions of the balloon were indeed minimal, but the speed of the balloon was not sufficient to carry it out of the great streamer of smoke and fog which stretches many miles down the wind from every great city. Nevertheless, he succeded in obtaining some excellent pictures. The new process is expected to have great meteorological and strategic value, and it is expected that cameras of his pattern, with three objectives, permanently placed color filters, and using plates 8 x 24 centimeters will soon be on the German market.

## ENGINEERING NOTES.

**The economy** shown by superheating is so well defined that there is now no question of its effective and substantial saving. Superheated steam locomotives, whether compound or simple, show about the same percentage of economy over an ordinary simple locomotive. A number of tests have been made with simple types of locomotives using superheated steam, in comparison with similar types of compounds, but as yet no definite conclusions, more particularly with respect to the successive superheating before the steam enters the cylinders of compound locomotives, have been arrived at. It is estimated that the use of superheated steam in connection with compound engines will give about the same results by reduced loss in cylinder condensation as the triple expansion of steam without the superheating.

**Plans have been completed** for the construction of a new type of vessel for the British navy. This craft is to be employed as a parent ship for torpedo boats and torpedo-boat destroyers, and will act simply as a directing base of operations, accompanying the mosquito craft on their raids. Speed is to be the all-important factor, and this new vessel will be fitted with sufficient engine power to insure a speed of 27 knots per hour, practically everything being sacrificed to attain this end. The craft will be 500 feet in length and will be of very light scantling, the only armament to be carried consisting of light, quick-firing guns. Abnormal coal bunker capacity is to be provided, so that the craft may have a wide radius of action and exceptionally large fuel endurance. The vessel will be shortly laid down at Pembroke dockyard, and is to be completed ready for sea in eighteen months.

**The application** of gas power by means of the portable gasoline engine on such farms where the cheapest forms of producing motion, viz., wind or water, are either not available or unreliable, and where steam power is too expensive and electrical energy cannot be had, has filled a long-felt want. On the continent this form has been superseded by the alcohol motor, which is now to become a claimant for recognition also in this country. The stockman, the fruit grower, the thresher, the mill owner, will readily testify to the comforts and savings which the evolution of this new

power has bestowed upon them. Yet we are only at the beginning of the new era. Just now the portable suction gas plant is coming into practical use in Germany, enabling the farmer, instead of buying expensive gasoline or converting potatoes or other valuable matter by a costly process into fuel alcohol, to take the straw or hay or sawmill refuse, or other vegetable matter growing on the farm, and feed it directly to the producer to be there gasified, generating the required power at no additional heat cost. In order to get the same work output with straw four times the weight of coal and forty times its volume must be burnt.

## SCIENCE NOTES.

**It is extremely important** to the subject of physiology that the methods which have made possible cytological advances shall be extended and utilized in developing a knowledge of all of the various activities of the cell. In this way, a clearer insight may be given of many abstruse metabolic processes; and certainly further light may be thrown upon the matter of protoplasmic decompositions and secretions, the production of enzymes and alkaloids, tannins, and other products. Going hand in hand with observations upon fresh material, the limitations of micro-chemistry alone should determine the possibilities in this direction of the work.

**From the earliest times** geographical information included other than topographical data. It was soon found that for the traveler and statesman, whether in peace or war, more was wanted to enable geography to supply requirements. The nature of a country, the supply of food and water, the character of the rivers, the manners and customs of the inhabitants, their language and affinities, the climate, and other matters, were all of much moment, and geography dealt with them all, being, as its name denotes, in the broadest sense a "description of the earth." After the first crude guesses of relative positions, founded on times occupied on journeys, other knowledge was enlisted in the cause. Astronomy was soon recognized as the only means by which to ascertain the distances of places far apart and separated by seas, but for many centuries this could only be applied to latitude. Still the scientific geographer had to study and use the astronomical and geodetic methods known.

**With the close** of the Franco-Prussian war in 1871 began the period of most rapid progress in all lines of technical education. After the unification of the German states a new economic force become apparent. Economic supremacy appeared as a goal to be reached through the aid of science and technology. The individual German states vied with each other in improving the equipment, strengthening the teaching force, and raising the standards of their technical schools. In 1879 the Bau-Akademie and the Gewerbe-Akademie, trade and building schools of long standing, were consolidated to form the present Charlottenburg Technische Hochschule, at Berlin. In 1879 the school at Hanover, in 1885 Karlsruhe, and in 1890 Dresden, advanced to the position of Technische Hochschule. Not alone in the higher schools but in trade, building, industrial, manual training, evening and extension schools improvement was marked, so that to-day the opportunities for obtaining a technical training of any character are greater in Germany than in any other country on the globe. The amount of money expended on these schools is enormous, and the great efficiency attained is admitted by all investigators of the subject. However large the expense may be the Germans believe that a full equivalent is returned to them in an enhanced industrial efficiency. Although progress is most marked in Germany, other countries have not been idle. Norway, Sweden, and Denmark have copied the German system and have a well-organized system of technical education with high-grade technical institutes at Stockholm, Goteborg, Christiania, Bergen, Trondjhem, and Copenhagen. Russia has followed the lead in the higher work and has well-appointed imperial technical institutes at St. Petersburg, Riga, Warsaw, Kiev, and Cracow. In 1896 the Institute at Moscow was reorganized and remodeled on the plan of the Institute at St. Petersburg. In Austria great strides have been made in all lines and the Technische Hochschule at Vienna ranks with the best in Germany. In Switzerland steady and persistent progress has been made in organizing a system, with the Federal Polytechnicum at Zurich at the head, which provides for the technical education of all classes of its people. The industrial life of Switzerland depends in no small measure upon the skill and knowledge obtained in her technical schools. France, too, has advanced, as her numerous trade and industrial schools attest. In England evening schools, polytechnics of trade school character, and technical schools of an inferior grade have flourished apace. Less advance in high-grade technical instruction has been made in England than in any other European country. The Central Technical College of London, founded as late as 1884, and a few other engineering colleges furnish the only professional engineering instruction in the United Kingdom. The influence of the Department of Science and Art and the numerous attempts to teach a trade under the pseudonym of mechanical engineering has resulted in a dearth of high-grade technical men and a plethora of half trained workmen. In the United States, as a result of the Morrill Land Grant Act, technical education of an engineering character has entered practically every one of our State universities. Private munificence has also added many independent schools to the list.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